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Seventeenth

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VOLUME NO. 17
OF THE
MARYLAND AGRICULTURAL
EXPERIMENT STATION,
COLLEGE PARK, MD.,
1903-1904.

THE
Maryland Agricultural Experiment Station.

CORPORATION.

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A. B. GAHAN, B. S.	*Assistant Entomologist.*
JOSEPH R. OWENS, M. D.	*Treasurer.*
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THOS. H. WHITE	*Gardener.*

The Station is Located on the B. & O. R. R. and City & Suburban Electric Car Line, 8 miles north of Washington, D. C.
Bell Telephone—Washington Directory—Hyattsville 42.

Visitors will be welcomed at all times, and will be given every opportunity to inspect the work of the Station in all of its departments.

The Bulletins and reports of the Station, will be mailed regularly, free of charge to all residents of the State who request it.

ADDRESS:

AGRICULTURAL EXPERIMENT STATION,
College Park, Maryland.

THE

SEVENTEENTH

ANNUAL REPORT

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MARYLAND

Agricultural Experiment Station,

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PRINCE GEORGE'S CO., MARYLAND.

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College Park, Maryland.

LETTER OF TRANSMITTAL.

To His Excellency, Edwin Warfield,
Governor, and President of the Board of Trustees,
Annapolis, Md.

Sir:—In accordance with the provisions of Section No. 3, of the Act of Congress, approved March 2nd, 1887, "To Established Agricultural Experiment Stations", etc., I have the honor to transmit the Seventeenth Annual Report of the Maryland Experiment Station for the fiscal year ending June 30th, 1904.

Very respectfully yours,

H. J. PATTERSON,

July, 1904.

Director of the Experiment Station.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Volume 17. 1903-1904.

Report on the Work and Expenditures of Maryland Agricultural Experiment Station.

FOR THE YEAR ENDING JUNE 30, 1904.

By H. J. PATTERSON Director.

The duties imposed upon an agricultural experiment station are quite comprehensive and varied yet there is one point which is commonly overlooked by the general public which in a measure circumscribes the work and function of the station. The law while giving a range of subjects for consideration yet specifically designates that the station shall conduct researches or experiments bearing directly upon the agricultural industry of the United States. Section 2 of the Hatch Act defines the work and it is as follows;

"That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments in the physiology of plants and animals; the diseases to which they are severally subject with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and waters; the chemical composition of manures natural or artificial with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different foods for domestic animals; the scientific and ecomomic questions involved in the production of butter and cheese and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable having due regard to the varying conditions and needs of the respective States or Territories."

Wide as is the range of work designated by this law, yet there are many things which it seems desirable to do so as to bring the work of the Station in touch with the people and in order to conform to public demands though it is not strictly research. All who have had to do with the practical working of an experiment station recognize that it is necessary to conform in a measure to the popular demands and notions of the practical farmers.

The demands for information, of a character which has long passed the experimental stage, by letter, by lecturers at farmers' meetings of various kinds, and by visit to individual farms is constantly on the increase.

This class of work draws heavily upon the time of the investigators and considerably lessens the amount of new information that can be acquired. Nevertheless it is deemed necessary for the Station to include this field of labor within its province and the only way that the full demands may be met will be to have the State provide for the expense incurred and so not encroach on the proper expenditure of the "Hatch" fund. As to the work in progress at this Station, it may be said in general that all has gone smoothly and that everyone connected with the Station has seemingly put forth their best efforts towards advancing the best interest of the Station as a whole, as well as the particular division with which they are concerned.

EXPERIMENTS IN PROGRESS.

Most of the experiments in progress were quite fully outlined in the sixteenth annual report so that it would seem unnecessary to repeat the list here, but only to make mention of the changes and additions which have been made during the past year.

AGRONOMY.

There have been no new lines of work taken up in this division during the past year, but some of those already in progress have been much broadened and developed. Particularly is this true of the work with corn and alfalfa.

The improvement of corn by breeding and selection has become of very much interest to Maryland farmers and has manifested itself by the organization of the Maryland Corn Breeders' Association. The work of this association can be of great benefit to the state when fully developed; but for full development they need the co-operation of an institution such as ours. In order that you may realize the great possibilities of the corn crop of the state, I will call your attention to the following facts;

There is grown in Maryland annually about 650,000 acres of corn yielding about six barrels or thirty bushels per acre. The work of this Station on corn breeding has shown quite conclusively that by following the results we have obtained, that the average yield should be raised at least ten bushels per acre. This increase would mean, at the average price for corn, over two and one-half millions of dollars more annually in the farmer's pockets. These corn investigations have not only shown that the yield can be increased, but also that the feeding quality can be improved. Average corn contains only about 8.5 per cent protein while most of the 800 samples of corn that have been analyzed, in connection with our investigations, have shown over 10 per cent protein and some samples as high as 12.5 per cent. Surely with such a prize before us there should be a greater effort than at present to accomplish the result, and the equivalent of one man's time could be profitably employed in this work. What is true of corn is also true of wheat, hay and pasture crops. There have been spasmodic efforts made to grow alfalfa in Maryland for more than twenty years, but generally the efforts have resulted in failures. It has now been shown that the soil upon which this crop is to grow must first be inoculated with a bacteria which will develop on the alfalfa root and enable the plant to utilize the atmospheric nitrogen. When this condition is provided there will be thousands of acres devoted to this valuable crop and result in the improvement of the fertility of the farms and cheapen the cost and increase the production of milk, butter, beef, pork, mutton and eggs.

CHEMICAL DIVISION.

This division, beside analyzing numerous miscellaneous samples during the year has determined the protein and fat in over 800 samples of corn in connection with the corn breeding work.

The investigations mentioned in the 16th report have been continued and studies on two new subjects begun, as follows;—

1st. Studies of the relative sweetness of different varieties of sweet corn. This work has been taken up as a basis for future experiments upon the breeding of sweet corn, so as to increase the sugar content and improve in other ways the qualities of sweet corn for the canning industry.

Maryland devotes annually about 17,000 acres to sweet corn andpacks about one million cases of corn. Most of this corn requires the addition of sweetening materials in order to meet the requirements of the trade. In view of our present knowledge of the corn plant we can reasonably expect, that by breeding, to produce a corn that is much richer in sugar than that grown at present, and also to improve this crop in many ways so as to make it better adapted to our climate and soils and also to the purposes for which it is grown. Maryland purchases annually , from other states, 3000 to 4000 bushels of sweet corn seed the bulk of which has been grown in the New England states. The yield of sweet corn in those states is from 40 per cent to 60 per cent higher than in Maryland. This fact coupled with repeated observations and comparisons with a Maryland grown variety has shown that, the Maryland seed is much better adapted to our climate than the New England seed. There are other sections giving the canners of this state strong competition in the canning industry, and it behooves us to look towards the improvement of our products if the state is to maintain her position of first in canned tomatoes and peas, and fourth in corn.

2nd. The second new line of work taken up by the chemical department is a study of the character and extent of the soil areas which contain an excess of soluble salts.

Our investigations have shown that some soils in Maryland contain a larger amount of soluble salts than exists in some of the alkali soils of the west. This condition is detrimental to crops and it is the purpose to study the character of these soluble salts and determine the means of correcting the difficulty. Then to locate the areas, as far as possible, and point out the crop symptoms which indicate this condition.

DAIRY DIVISION.

In addition to the work outlined in the 16th., report, the dairy division has completed investigations and prepared them for publication on the following subjects;—

1. A study of the change in milk during the period of heat of the animal.
2. Comparison of the feeding values of alfalfa hay, corn silage, cow pea silage.

3. A study of herd records as to the proper time, during the milking period, for making weighings and fat tests.

In addition to his regular duties Mr. Doane spent considerable time, during the past year, in going over the State to collect data and in preparing a booklet on "The Dairy Industry in Maryland" for the St. Louis Exposition Commission.

The dairy division has under way a study of the initial acidity of milk with a view of fixing a basis for determining when milk is too old for use.

This division is now preparing to collect some data to determine the relative profits of making butter on the farm, at a creamery, shipping milk or shipping cream, and also at the same time obtaining figures to show the relative profits in dairying, as conducted by the uninformed and the up-to-date dairyman.

HORTICULTURAL DIVISION.

The new work started during the past year, in addition to that given in the 16th., report, is as follows;

1st., The extension of the work on cover crops and orchard cultivation.

2nd., A study of various ways of pruning the peach.

3rd. A cherry orchard of nineteen varieties was started this spring.

4th. A nut orchard, consisting of the leading varieties of American and Japanese chestnuts, American and English walnuts, butter nuts, hickory nuts, pecans and filberts, has been started.

6th. An investigation of the efiect of different kinds of stocks upon which to work apples and pears has been begun.

The small fruit plantation set out in 1903 promises fine results for this season. So far the indications are for good crops of currants and gooseberries. Of the nine varieties of red rasp-berries planted, only one variety can be said to be good, two varieties fair, and six, either total failures or very poor. Of the eleven varieties of black rasp-berries, three are good, three fair, and five very poor· Of the twenty varieties of black-berries, ten are good, three fair, and seven poor.

DIVISION OF BOTANY AND PLANT PATHOLOGY.

Most of the time of those employed in this department has been spent in the inspection work incident to the carrying out of the provisions of the State Horticultural Law. One of the chief duties imposed by this law is the control of peach yellows, and it is gratifying to note that when this work was started, five years ago, 20 per cent of the trees inspected were found to be diseased while the past year's inspection showed only two per cent.

The following new lines of work have received attention during the past year, in addition to those listed in the 16th., report.

1. An orchard of 75 trees has been set to make a study of crown gall on apples.
2. Comparison of dust and solution spraying.
3. A study of the varieties of fruits and vegetables resistant to diseases.
4. Cabbage diseases.

5. Corn Smut.

6. A study of the effect of fertilizing elements on the natural vegetation in open uncultivated fields.

7. The Assistant Botanist has started on a preliminary study of the types of tobacco grown in the states, in relation to the soils and conditions, with an idea of doing some work in breeding and selection so as to improve the crop from the seed and variety stand-point. This work would seem to be productive of valuable results but will need more time devoted to it.

The pathological and entomological divisions are badly in need of a specially constructed green house, in order to carry forward their investigations, and as the provisions have been made for the house, I think it would be well for the experiment station to give as much help as possible towards procuring the necessary equipment for the same.

DIVISION OF ENTOMOLOGY.

The most of the time of this divison, as well as that of Botany, has been spent in the State Horticultural Inspections. The work of this division has been done at a disadvantage owing to the frequent changes of the assistants. There have been three changes in this position during the year. These changes have been caused by voluntary resignation in order to accept better paying positions elsewhere. This division has inspected over 700,000 fruit trees during the past year, of this number about 15 per cent being found to be infested with San Jose scale. During the past spring, under advice from this department, about 377,000 trees have been sprayed for the scale.

This division is continuing the investigations listed in the last report and has satisfactorily inaugurated a series of experiments for controlling the ravages of the root maggot, on cabbage, which has been quite prevalent this year.

VETERINARY DIVISION.

This division being connected with the Station largely, in a consulting capacity, does not devote much time to investigations, and nothing has been taken up during the past year. The veterinarian made during the past month the annual tuberculin test of the herd, and found twelve of the young and old to respond. These animals were disposed of at once.

The results of these tests has given some valuable data for the study of the hereditary tendency of the disease; but as the disease has, in most cases, been found to exist in our best cows and cows most valuable in connection with other investigations, it will be seen that this trouble has been serious to our work as well as caused considerable financial loss to the institution. Some recent discoveries give some hope of being able to cure the disease. If successful, this will prove of great advantage to the dairy industry, for there seems to be but little doubt but that tuberculosis can be transmitted from animal to man. Observations have shown that a dry atmosphere and stables that are well ventilated and which admit of considerable sunlight in all parts, are freer from this trouble than are the dark ones.

CO-OPERATIVE AND DEMONSTRATION EXPERIMENTS.

The co-operative experiments outlined in the previous report are still in progress. There is more room for work of this nature, but from past experiences we have found that it is useless to undertake such experiments, unless detailed supervision of them can be given by persons trained in such work and also unless the station is ready to meet all the extra expenses incurred in them.

We have numerous demands made upon us from time to time for investigations to be conducted in various parts of the state so as to meet the local conditions. We grant that such tests are desirable and valuable, but few of those who ask for such work realize the difficulties which attend it or the time and expense that would be involved.

Not only would it be desirable to conduct experiments in different parts of the state, but many times the demonstrations of the results obtained here would be valuable in enabling the station to reach the people in a way that a bulletin can not, and in getting them to adopt many things which would be of great advantage.

There has come to us from citizens in Harford and Caroline counties a suggestion that would seem to offer an opportunity to do such work and to solve the difficulties which has confronted it. The suggestion is as follows; That the Alms house farms, which are maintained by most of the counties, should be placed in charge of a trained superintendent and a man capable of conducting investigations under the direction of the Experiment Station, and that such farms be used as *co-operative and demonstration farms* by the Experiment Station. I believe, the idea, is a good one and could be carried out at a small additional cost to each county, and that the results which would accrue to the farmers in the different counties would be of inestimable value and that such farms would really become a source of profit to a community, instead of a dead tax.

SEED GROWING.

This is a time when more attention is being paid to the character of seed used, and it has been fully demonstrated that the quality of seed has much to do with the quantity and quality of the crop. Again it has been shown that for best results, seed should be from acclimated plants. In view of these facts, and the fact that Maryland is giving more and more attention to growing truck and other crops, which are so materially influenced by the quality of the seed, it seems to me that it has become of paramount importance that our farmers and truck growers be impressed with the necessity of using better seed, and if possible, using home grown seed, or at least having seed grown from plants adapted to our soil and climatic conditions. This question brings up to many farmers the feasibility of growing seed, and I believe offers an opportunity to many of the farmers, especially those located in isolated sections, to grow seeds instead of the more bulky staple crops. Seed of all kinds when pure and clean sell at good prices, and when a preference is once established for home grown seed the prices for local growers will be much better. It would seem desirable for the station to do some work upon this subject.

PUBLICATIONS.

In addition to the annual report the following bulletins have been issued;

No. 90. Results of experiments with different spraying solutions for the San Jose scale, by T. B. Symons.

No. 91. Experiments with Nitrogenous fertilizers, by H. J. Patterson.

No. 92. Notes on apple growing in Maryland, by C. F. Austin.

No. 93. Second report upon the pithiness in celery, by C. F. Austin and Thos. H. White.

In addition to the regular bulletins the entomologist and pathologist have issued the following circular bulletins;

Circular bulletin No. 54. How to treat the San Jose Scale, by T. B. Symons.

Circular bulletin No. 55. The Study of Insects in the public schools, by T. B. Symons.

Circular bulletin No. 56. Crown Gall, J. B. S. Norton.

Circular bulletin No. 57. Some insects that attack fruit trees in spring, by T. B. Symons.

Circular bulletin No. 58. Cabbage diseases and insects, by J. B. S. Norton and T. B. Symons.

The publications of the Station are meeting with a constantly increasing demand and are being more and more appreciated. All of the publications of the College and Experiment Station should reach every farmer in the State. The matter which goes into the publications should be indexed and placed in a form which will enable the farmers to preserve them and be able to refer to particular subjects from time to time as needed.

At the present time there are three series of publications going out from the College and Station to the farmers. For this purpose there is maintained three separate mailing lists all of which used the original Station list as a basis. The farmers of the state do not distinguish between the departments of the college and the station and after applying for one set of publications naturally expect all.

Under the present system he may get only one or all of them; but a new applicant's name must be forwarded from one department to another and entered up three times, to insure him getting all he may desire. This transmission of names to all the lists is frequently neglected. In order to overcome this difficulty and put all the departments in better shape to serve the public and also in the interest of economy the mailing division of all the departments could be merged into one office thus preventing the going over much work three times in keeping three separate lists, and at the same time, enabling the other departments to avail of the complete, modern and most approved mailing outfit, already owned by the Experiment Station. In this way the station could save the other departments the expenses of following the details of keeping up and correcting a mailing list, and the only expense they would be at, would be the actual cost of envelopes and labor in mailing.

THE FARM.

The policy in the management of the station farm has been to make all of it contribute directly or indirectly to the investigations in hand, and it has never been the aim, and I doubt if it is possible with such a purpose in mind to make a station farm a commercially profitable enterprise. The very nature of experiment station work makes the amount of labor necessary from three to one hundred times as great as would be required for the same area under cultivation in ordinary farm practice. In order that field experiments will be as reliable as possible the work must be given prompt and careful attention and there should be sufficient force at command to enable all the work on things which are to be compared, to be done at one time and under uniform conditions. This means that all the experiments must take first place and any work on the general farm operations, be a secondary consideration. These facts will enable those not familiar with such work to understand the reason for the amount spent for labor.

BUILDINGS.

During the past year, some few repairs have been made which seemed imperative and necessary.

According to instructions, one house for farm hands has been built during the past year. By using some old material on hand a very good five room house, with cellar under a portion of it, has been obtained at a cost of about $650.

During the winter some needed clearing along the branch was done, and at the same time there has been saved enough lumber for framing and sheathing a six room house. The funds of the Station will permit of the construction of such a house the coming year.

The heating plant in the main station building is in an unsatisfactory condition. The way it is installed it not only does not heat the building comfortably, but it is costing much more to run than it should. I have investigated the matter of the renovation of the heating plant and find that it can be put in good shape at a cost of about $300. When this is done more than one-half of the fuel can be saved and it will require only about one-third the attention.

DRAINAGE.

Many parts of the farm are too wet for use in connection with experiments and some parts even too wet to be cultivated at all. This condition was very pronounced during the last two years, and for lack of drainage the value of the crops injured was greater than would be the expense of having the land drained. These parts should all be drained when possible. During this spring we have had all the old open ditches thoroughly cleaned out and several new open ditches dug, and have also put in about 1200 feet of two-inch tile drain.

THE AGRICULTURAL INTERESTS OF MARYLAND.

In order that you may have an idea of the relative annual returns from various agricultural interests of our farmers, and in order that you may better appreciate the reasons for some of the statements and recommendations made in this report, I have compiled the annual value of the farm and animal products and give them herewith in the form of a pyramid.

While none of the subjects which are receiving the Station's attention are getting anything more than is deserved, or more than can be turned to profit, yet I believe that some things, particularly the corn, wheat and forage crops not only merit, from their relative importance, but offer opportunities for much more work that would prove immensely profitable to our agricultural interests.

Small Fruits,	$1,224,000.00.
Potatoes,	$1,337,000.00.
Orchard Fruits,	$1,416,000.00.
Tobacco,	$1,436,000.00.
Miscellaneous Products,	$1,792,000.00.
Vegetables,	$4,354,000.00.
Hay and Forage,	$4,709,000.00.
Wheat,	$6,484,000.00.
Corn,	$7,463,000.00.
Total Value,	$30,217,000.00.

FARM PRODUCTS.

Honey, Wax,	$39,000.
Wool,	$143,000.00.
Poultry and Eggs,	$3,650,000.00.
Pork, Beef, Mutton,	$,546,000.00.
Dairy Products,	$5,229,000.00.
Total Value,	$13,607,000,00.

ANIMAL PRODUCTS.

STATION EXHIBITS AT FAIRS.

Last fall the Station made exhibits of its work at seven of the fairs held in the State. We could not attend the other one as it fell in the same week with another fair.

This exhibit was planned after the outline given in their 15th annual report. While the exhibit was far from being in as good shape as desired; yet it was well received and I believe productive of a great deal of good. The departments of Agriculture, Horticulture, Botany and Entomology, were all represented in the exhibit, and these departments all deserve credit for the interest shown in this work and for the material contributed.

Ever since the close of the last fair season we have employed most of the time of Mr. E. P. Walls, one of the graduates of the College, in getting things in shape for the next fair season and think the exhibit which will be made at the fairs the coming fall will be the best that the

Station has ever made and should not only contribute to the general interest in the fairs, but also will give the farmers valuable object lessons which they can take home and apply and make the few minutes, spent in looking at such an exhibit of great profit.

There is no doubt but that object lessons, such as can be shown by such exhibits, are the most instructive and far reaching of anything which can be placed before the public and that this means of placing the results of our work before the farmers will do them more good than many times as much spent in printing bulletins, etc.

In order to extend the scheme of exhibits and to be able to reach more people than can be done at the fairs alone, I have been at work on the idea presented to and approved by the Board of Trustees at the October, 1903 meeting of installing the exhibit in a car, and taking the same to each town in the State where a farmers' institute or other farmers' meeting is to be held. I presented this matter to the industrial agent of the Baltimore and Ohio railroad and they have promised to co-operate with us in this work to the extent of furnishing a car for the purpose and hauling the same free to points reached by their road. I trust that this plan will be put in shape to be utilized during the coming winter.

The Botanical, Chemical and Entomological departments of the station have all prepared some matter showing the special features of our work for exhibit at the collective exhibit of the Colleges and Experiment Stations of the United States at St. Louis, and all of the departments of the Station made contributions of material, labor, etc., towards the Maryland Agricultural Exhibit at St. Louis.

STATION STAFF.

I desire to call particular attention to a few matters pertaining to the scientific working force of the Station, which needs special consideration at this time. The attitude taken last winter by the U. S. House of Representatives in making the appropriation to the stations in trying practically to take the control of these institutions out of the hands of the State Boards of Trustees and placing it under the U. S. Secretary of Agriculture, was largely induced by the feeling that the Stations were not devoting the time of the workers and were not spending the Hatch funds strictly for investigation purposes. There is quite a wide and prevailing sentiment in the minds of those who are looking after the expenditure of the Hatch fund that the experiment stations should have, in the main, a working force of investigators separate and distinct from the teaching force of the College. This idea is being put in practice to some extent by some of the leading experiment stations. From a recent, (May 26th) communication received from the U. S. Department of Agriculture concerning the policy of the stations and the expenditure of the Hatch fund, the above idea was set forth, and reinforced by the following statement: "In making the division of salaries, account must be taken that a college officer has other duties than those in the class-room, that if college work is heavy, even though it may leave him unoccupied hours, little investigation can be accomplished in fragments of time, and that as a rule, the undivided time of one man is worth considerably more to the station than half the time of two men with college duties."

"In view of the feeling that exists, and the common interests of the stations which are involved, the managers of stations are urged to take great care to provide that the Hatch fund shall be used exclusively for strictly experimental purposes. The enlargement, if not the continuance of Federal support of the Stations depends very largely on convincing Congress that the National funds granted from year to year, for this purpose, will be strictly applied to purposes of Agricultural research as distinguished from agricultural education."

In view of these facts and the attitude of the authorities in Washington, D. C., and of the fact that some of the work here has grown to such an extent that it is no longer possible for those who have the investigations in charge to give the detailed attention that is now required. I would advise that the station employ, during the next year, an assistant in agronomy and an assistant in horticulture, both of which shall devote his entire time to station investigations upon these subjects. The present financial condition of the station will justify this expense, and I feel sure will meet with the approval of the farmers of the state as is evidenced by a resolution passed at the annual meeting of the farmers' clubs, which is as follows:—

"We think the Prof. of Agriculture has to give divided attention to too many lines of work, to be able to do his best in any one line. He is required to give one-fourth of his time to the Experiment Station, in pursuing original investigations in Agriculture. The investigations in progress with the staple crops are very interesting, and offer great opportunity for profit to the farmers of the state, and we recommend that provision be made, so that the equivalent of the time of one man might be devoted to this division of the work."

During the past year there has been less changes in the station staff than for some years, yet more than desirable for work of this kind. The following is a list of those which occurred:—

Assistant Entomologist Ralph Smith, resigned in August 1903, to accept a similar position at higher salary with the Georgia State Board of Agriculture. This vacancy was filled in October by the appointment of F. C. Bishopp of Colorado; who remained here until January, then resigned to accept a position in the division of Entomology of the United States Department of Agriculture. The vacancy thus caused was filled by the appointment, in February, of A. B. Gahan, a graduate of the Kansas Agricultural College. The assistant Entomologist has but a nominal connection with the Experiment station as the duties of the position are mainly in connection with the State inspection of orchards and nurseries. C. F. Austin, associate horticulturist, has handed in his resignation to take effect July 1st. He has resigned to accept the position of horticulturist of the Cuba Experiment Station at a considerable increase of salary.

FINANCIAL CONDITIONS.

As will appear from the report of the treasurer, the fiscal year will close with all bills paid and a small balance. I have carefully gone over the probable expenses for the coming year, and I believe that the station is in position, as far as funds are concerned, to carry out all the recommendations made in this report.

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE STATION FARM.

DR.

1903.		
July 1,	To cash balance	$ 128.65
	To sales of stock and produce, during the year ended June 30, 1904	4468.25
		$4596.90

CR.

1904.		
June 30,	By labor,	$2271.86
	By seeds, plants and seeding supplies,	245.00
	By fertilizers,	250.00
	By feeding stuffs	1200.00
	By live stock	350.00
	By contingent expenses	277.91
	By cash balance	2.13
		$4596.90

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE STATE OF MARYLAND APPROPRIATION.

DR.

1903.		
July 1,	To cash balance,	$ 13.64
1904.		
June 30,	To receipts from the treasurer of the State of Maryland for the fiscal year ending September 30th, 1904, as per Sec. Chap. laws of 1902	5000.00
		5013.64

CR.

1904.		
June 30th,	By exhibits	$ 1794.01
	By publications,	830.31
	By feeding experiments,	248.25
	By buildings and repairs	1129.79
	By cash balance	1011.28
		5013.64

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

DR.

1904.		
June 30,	To receipts from the treasurer of the United States, as per appropriation for the fiscal year ended June 30, 1904, as per Act of Congress of March 2, 1887,	$ 15,000.00

CR.

1904.		
June 30.	By salaries,	$ 7259.78
	" labor,	2927.98
	" publications,	209.31
	" postage and stationery	181.73
	" freight and express,	497.44
	" heat, light, water and power,	414.90
	" Chemical supplies	260.68
	" Seeds, plants and sundry supplies,	600.10
	" fertilizer,	256.32
	" feeding stuffs	387.28
	" Library,	298.84
	" Tools, implements and machinery,	615.16
	" Scientific apparatus	40.62
	" live stock, 452.00	452.00
	" traveling expenses,	163.83
	" contingent expenses	15.00
	" buildings and repairs,	419.03
		$15000.00

The above is a true copy from the books of this office.

JOS. R. OWENS,

Treasurer Maryland Agricultural Experiment Station.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 90. **December, 1903.**

THE SAN JOSE SCALE.

By Thomas B. Symons.

INTRODUCTION.

No greater factor ever confronted Maryland orchardists than the advent of the San Jose Scale into the State. With its pernicious habit the insect has succeeded in devastating many of the promising orchards and discouraging some of the enthusiastic growers. Nevertheless taking into consideration the amount of damage it has and is still doing there is no doubt that the San Jose scale will, on the whole, be what may be called a benefit to the horticultural interests of the State. It has called the attention of the large as well as the small growers to their trees and taught them by sad experience, in some cases, that the mere fact of planting an orchard is not all that is necessary in order that in a few years they may secure a crop of fruit. It has taught them that the trees must be continually looked after and if they wish to have a good healthy productive orchard, they must make a thorough study of it in relation to its culture and the diseases and insects to which it is subject.

The necessity of treating trees infested with the San Jose scale need hardly be repeated here, for it should be generally known that to neglect such work inevitably means the death of the trees. If your orchards are infested with scale you have the alternative of taking the matter in hand or sooner or later giving up fruit growing. It has been thoroughly demonstrated in many of the Eastern States, including Maryland, that this insect may be satisfactorily controlled by the employment of practical remedial measures, but it should be distinctly understood that the work must be thorough, and continued from year to year. Where the scale has become established, there is but little likeli-hood of it ever being eradicated, except in exceptional cases. Consequently efforts should be expended towards reducing its ravages to a minimum. Further we must fully realize that the San Jose scale is with us to stay, and when established, provisions must be made for keeping it in subjection as a part of the routine of orchard work.

As numerous inquiries regarding the life history of the insect are continually received and as the previous publications on the same from this station have been exhausted, it has been thought best to give briefly the description and life history of the pest for the benefit of those persons who are not as yet familiar with its habits.

GENERAL DESCRIPTION.

A tree when badly infested with the San Jose scale presents a somewhat grayish appearance as if it were coated with ashes, but to the ordinary observer the tree would hardly seem to be infested unless very closely examined. However, if one should attempt to scrape the bark, this process would reveal the same to be covered with numerous little scales of varying sizes beneath which lay the small oval, orange colored, soft, jelly-like objects which are the true insects. If the examination be made in the summer time the young yellowish lice would be seen crawling about and over the scales as shown in the illustration. (see fig. 1.) The presence of scale on a tree is most readily detected by examining the fruit. There is usually around each scale a bright red ring caused either by the effect of secretions of the insect through its beak on the tissues, or by a change in the epidermal cells brought about by the irritation of its setae in the tissues. The insects seem to be more thickly distributed around the calyx on apples (see fig. 2) and pears, while on peach they are more numerous at the stem end. In examining fruit especially pears, one must be careful not to take a spot caused by the pear leaf blight for a scale insect. The scale can always be distinguished by lifting the cover or scale from the insect. It is easier to observe the scale on the smooth bark of the twigs, than on the trunks and branches, for as on the fruit, they are usually surrounded by bright red rings, which extend below the bark into the wood. On badly infested trees during the growing season the scale will also be seen on the leaves, usually in clusters along the midrib and veins.

If an adult female insect is examined under a magnifying glass a small grayish circular scale about 1-24 of an inch in diameter, the centre of which is convex forming a slight nipple, will be seen, also numerous concentric circles can be seen around the nipple, the scale developing by additions to the outer edge. As mentioned before, beneath the scale is the true jelly-like individual. The color of the scale is variable. In the half mature insects the scale is quite black, and it gradually becomes grayish when approaching the adult state.

LIFE HISTORY.

The life history of the San Jose scale differs from most insects of this class as it winters as a partially mature insect under the scale. Early in the spring it begins to develop and about the first of May in this latitude the adult male emerges from beneath the scale as a minute winged insect. The female reaches maturity about a month later and begins to produce its young soon afterwards. The female lays no eggs but brings forth living young; the eggs develop and hatch within the body of the mother. The period of reproduction of a female extends over about six weeks and her progeny at that time will number about 400. The young insects are extremely small, yellowish in color and resemble small mites. They have six legs, a pair of antenae, and a long thread like beak through which they extract the juices from the plants when they become fixed. They crawl around on the surface on which they happen to be for some six to twelve hours in search of a suitable place to insert their beaks and if females to remain there the rest of their lives. In about a month from the date of birth the young scale insects reach maturity and the females then commence reproducing. As there are about four generations during a season in this latitude, with their great reproductive power, is it any wonder that this orchard pest increases so rapidly where no effort is made to hold it in check?

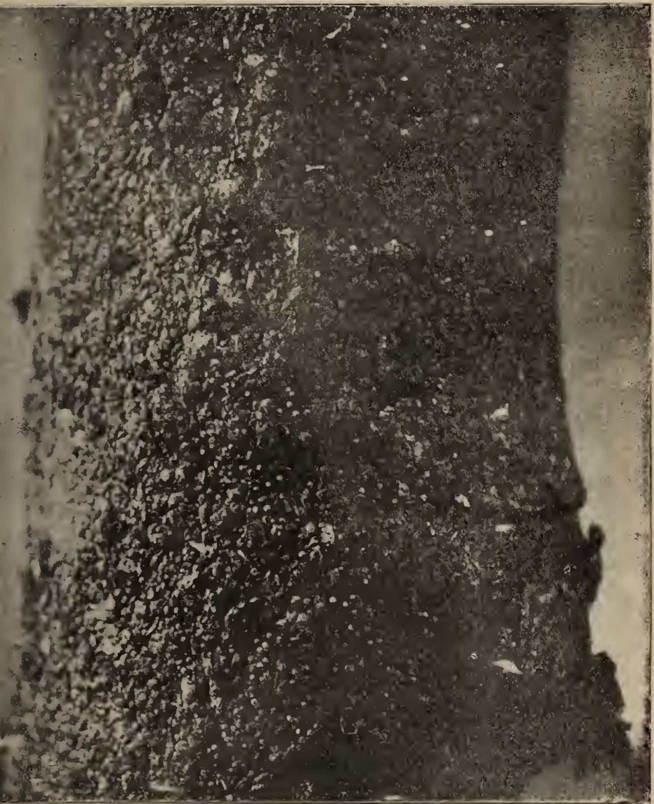

FIG. 1. A branch badly infested with San Jose Scale.

MEANS OF DISTRIBUTION.

Although the young of the San Jose scale are so tiny and are only able to crawl around on the infested tree for a period extending over about twelve hours and cannot of themselves reach other trees, yet it is evident that the insect is distributed from tree to tree and from orchard to orchard. This is accomplished by many outside agencies; first, it may be distributed on nursery trees, however this means is protected against by law; second, by the wind, which in blowing over an infested orchard may carry some of the young larvae on numerous particles which it twirls along to other trees in the vicinity; third, birds and various insects are responsible for carrying the scale, sometimes long distances, on their feet and bodies. There is also some danger of the larvae being carried by men and domestic animals in going through an infested orchard. It is likely that they hit the branches of some of the trees and in this way are the means of transporting the insect from tree to tree. Thus it is apparent that great care must be exercised to avoid the distribution of this pest.

COMBATIVE METHODS.

With the introduction of this insect in the East a renewed interest was manifest by experimenters with the different contact insecticides. It was long known that kerosene emulsion and soap emulsions were effective in controlling the majority of the common scale insects and accordingly these were recommended against the San Jose scale. Fumigation also has been employed but, though effective, it is rather an impracticable and costly remedy to employ in large orchards. But with the enormous increase of this pest in the East, much concern on the part of the orchardist was evoked in securing the most practicable, effective and cheap remedy to control its ravages. To meet this demand the Kerowater pump was put on the market, which enabled the orchardist to spray his trees with kerosene in mechanical mixture, and thus save the trouble of making the emulsion. But while this pump did satisfactory work when in careful hands, it was found that it could not be depended upon to spray the exact strength at all times when used by ordinary labor, and as a result, injury to the tree has frequently been occasioned. But at best kerosene or any of the mineral oils have not proved to be very satisfactory treatment for the San Jose scale. There is always some danger accompaning its use for if allowed to run down the trunk to the roots, its injury to the tree is apparent. It has also been found that continually spraying trees year after year with oils will have a bad effect on the bark.

Whale Oil Soap is an effective treatment against the pest, but its expensiveness has no doubt prevented its adoption. But where it has been applied to the trees just before the buds begin to swell in the spring, much good has been derived from its use.

Experimenters and orchardists have therefore been anxious to secure a remedy which can be applied on trees while in the dormant state without the slightest danger of hurting them. Before the advent of the scale in the East, it was successfully controlled on the Pacific coast with the lime, sulphur and salt or California wash and it was first thought that this wash could be employed against the pest in the East but the earlier experiments conducted with it were reported unfavorably, due apparently to the fact that examinations as to the effect of the treatment were not made late enough. However, later experiments have proven that the wash was equally as effective in controlling the insect in the East as in the West.

Experiments with this wash, in this State, were begun by Prof. A. L. Quaintance, State Entomologist, in the spring of 1902, and were made

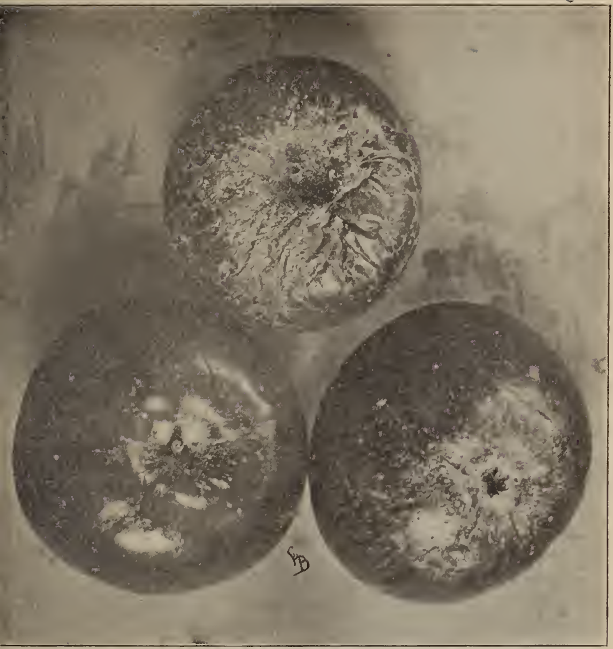

FIG 2. Shows apples badly infested with San Jose scale. (Photo by F. H. Blodgett,)

in four different parts of the State. Careful observations were made in these experiments from time to time, and an exact record of weather conditions was kept. The results have been reported in detail by Prof. Quaintance in Bulletin 37, New Series, Division of Entomology, U. S. Department of Agriculture and need not be considered here. It was found that this wash was a slow acting one and continued to kill the insect through August and September. By that time a tree sprayed with the wash in March will be practically free from the insect as the old female scales die about July, and the wash on the tree kills the majority of the young.

Prof. Quaintance published several circulars recommending this wash to the orchardists of the State. (Circular bulletins 44, 45 and 46).

TABLE I.

Experiments with Summer Washes. Conducted on the farm of J. W. Disney, Admiral, Md.

Plats	No. trees	Kind of trees	Condition of trees	Kind of Treatment	Formula	Strength	Time of application	% live scale before treatment	% live scale after treatment	Time of examination	Effect on trees	General remarks
1	1	apple	badly infested 20 % terminals dead	whale oil soap	1 ℔ to 1 gallon water		June 25, 1902	86.73	12.01	July 7-15 1902	foliage injured slightly	
2	2	"	"	"	1 ℔ to 1½ gal. water		"	87.08	13.62	"	"	
3	3	"	"	"	1 ℔ to 2 gal water		"	83.28	21.13	"	no injury	
4	3	"	moderately infested	"	1 ℔ to 2½ gal. water		"	74.34	18.91	"	"	
5	3	"	badly infested	"	1 ℔ to 3 gal water		"	80.83	27.58	"	"	Later examinations showed the scale to be rapidly increasing.
6	3	"	badly infested 20 % terminals dead	"	1 ℔ to 3½ gal water		"	87.76	37.27	"	"	
7	3	"	badly infested	"	1 ℔ to 4 gal. water		"	84.01	27.27	"	"	
8	3	"	moderately infested	"	1 ℔ to 4½ gal. water		"	73.78	44.21	"	"	
9	2	"	badly infested	"	1 ℔ to 5 gal. water		"	81.61	50.40	"	"	

TABLE I.—(Continued).

Experiments with Summer Washes. Conducted on the farm of Richard Disney, Admiral, Md.

1	6	peach	badly infested	whale oil soap	1 ℔ to 1 gal. water		July 11, 1902	87.54	15.54	July 15-20, 1902	foliage injured slightly	
2	6	"	"	"	1 ℔ to 1½ gal. water		"	87.58	15.43	"	"	
3	6	"	"	"	1 ℔ to 2 gal water		"	96.74	13.46	"	no injury	Later examinations showed the scale to be multiplying very fast.
4	6	"	"	"	1 ℔ to 2½ gal. water		"	90.86	20.05	"	"	
5	6	"	"	"	1 ℔ to 4 gal. water		"	89.19	23.36	"	"	
6	6	"	"	"	1 ℔ to 4½ gal. water		"	91.84	27.71	"	"	
7	6	"	"	kerosene emulsion	ker. 10 gal. soap 2½ ℔ water 5 gal.	15%	July 15, 1902	92.85	11.67	July 22 to Aug. 4, 1902	"	
8	6	"	"	"	"	20%	"	93.90	5.40	"	"	Later examinations showed that the 20 or 25 per cent kerosene or lime-kerosene emulsions to be the best summer wash used.
9	6	"	"	"	"	25%	"	93.49	1.69	"	"	
10	6	"	"	lime kerosene emulsion	lime 5 ℔ ker. 9 gal. water 4 gal.	15%	"	89.76	21.83	"	"	
11	6	"	"	"	"	20%	"	90.50	2.56	"	"	
12	6	"	"	"	"	25%	"	91.65	3.34	"	"	

TABLE I.—(Continued)

Plats	No.	Kind of trees	Condition of trees	Kind of treatment	Formula	Strength	Time of application	% live scale before treatment	% live scale after treatment	Time of examinations	Effect on trees	General remarks
13	6	peach	badly infested	Oregon wash	lime 15 lb sulphur 15 lb blue stone 1¼ lb	reduced to 75 gal.	July 15, 1902	88.71	.41	July 22 to Aug. 4, 1902	severe injury	
14	6	“	“	“	“	reduced to 100 gal	“	89.30	3.73	“	“	Trees hurt by wash.
15	6	“	“	“	“	reduced to 125 gal	“	92.15	3.71	“	“	
16	6	“	“	crude petroleum emulsion	cr'd petroleum 8 gal. soap 2 lb water 4 gal.	10%	“	89.39	4.89	“	slight injury	
17	6	“	“	“	“	15%	“	80.40	3.01	“	considerable injury	
18	6	“	“	“	“	20%	“	92.18	.50	“	severe injury	Trees hurt by wash.
19	6	“	“	“	“	25%	“	82.5	.50	“	“	

EXPERIMENTS.

With a view of further demonstrating the effectiveness of the lime, sulphur and salt wash, the most practical method of making and applying it, the best formula and the most effective time of application together with using it in comparison with other remedies, extensive experiments were undertaken by Prof. Quaintance in the fall of 1902 and the spring of 1903. He however resigned his position here in April and it befalls the writer to publish the results of these experiments and of those conducted during the summer of 1902, together with as much other data as could be obtained since having charge of the Department. It is also due Mr. R. I. Smith, Assistant Entomologist (resigned August 1, 1903) to say that the majority of the notes from these experiments were taken by him.

Many thanks are now expressed to persons who so kindly let us use their orchards and who contributed otherwise in the futherance of the work to control this pernicious insect.

While a number of different washes used proved to be of no economic importance yet it seems that such work should be reported to show what this department is doing. For convenience the experiments will be classified as summer, fall and spring applications.

EXPERIMENTS WITH SUMMER WASHES.

It was first wished to know what strength of whale oil soap could be applied in the summer without injuring the trees and correspondingly what effect this strength would have upon the insect. Therefore nine plats of apple trees were sprayed June 28, 1902 with whale oil soap at J. W. Disney's, of Admiral, Md. The first plat was sprayed with whale oil soap at the rate of one pound to the gallon of water and each plat thereafter sprayed with a solution increasing the water one half gallon to a pound of soap. It may be said that the soap solution was made in the usual manner by heating water and dissolving soap in it. In these as well as in the succeeding summer experiments about one half dozen pieces from different branches in the trees were taken and the per cent of live scale determined, also after sufficient time had elapsed after treatment another count was made in a similar manner to determine the per cent of live scale after treatment. By consulting table I, page 6 the reader will see that no injury was apparent to the tree when sprayed with one pound of the soap to two gallons of water and up, but only a small per cent of the insects were killed; and only slight injury was caused by spraying with the soap solution at the rate of one pound to the gallon. This strength can therefore be used in the summer, however it will only hold the insect in check for a time.

Further experiments with whale oil soap, kerosene emulsion, lime-kerosene emulsion, Oregon wash, and crude petroleum emulsion were undertaken at Mr. Richard Disney's, Admiral, Md., July 11, 1902. By consulting table I, page 7 and 8 there will be seen the formulae and the different strengths used at each treatment. In these experiments also the solutions were made in the usual manner. From the results given it is evident that the 20 or 25 per cent kerosene emulsions are the best summer treatment. While the lime-kerosene emulsion is a close second and may have an advantage over the regular emulsion in that it may not hurt the foliage quite so badly. The Oregon wash and the crude petroleum emulsion used at the stated strengths appear to injure the foliage severely.

TABLE II.

Experiments with Early Fall Washes. Conducted on the farm of Alfred Louds, Chestertown Md.

Plats	No. Trees	Kind of trees	Condition of trees	Kind of treatment	Formula	Strength	Manner of preparation	Time of application	Time of examinations	per cent scale killed	Effect on trees
1	25	peach	badly infested	lime, sulfur and salt	stonelime 40 ℔ sulfur 20 ℔ salt 15 ℔ water 60 gal.		boiled for 1½ hours	Sept 10, 1902	Sept. 17 and 30, 1902	about 75 %	severely injured
2	25	"	"	"	"	reduced to 80 gal. water	"	"	"	"	"
3	6	"	badly infested severely prun'd	whale oil soap	2 ℔ to 1 gal. water		dissolved soap in warm water	"	"	90 %	"
4	4	"	badly infested ordinarily pruned	"	"		"	"	"	"	"
5	25	"	badly infested not pruned	"	2½ ℔ to 1 gal. water		"	"	"	"	"
6	41	"	badly infested	Oregon wash	lime 15 ℔ sulfur 15 ℔ blue stone 1½ ℔ water 50 gal.		boiled for 1½ hours	"	"	"	"
7	41	"	"	"	"	reduced to 75 gal.	"	"	"	85 %	"
8	41	"	"	kerosene emulsion	kerosene 10 gal. soap 2½ ℔ water 5 gal.	20 %	made in usual way	"	Sept. 18 and 30, 1902	90 %	slightly injured foliage

TABLE II—Continued

9	41	"	badly infested	"	"	25%	"	"	"	"	"
10	41	"	"	California summer wash	caustic soda ½ ℔ " potash ¾ ℔ soap 20 ℔ sulphur 2 ℔ water 25 gal.		"	"	"	50 %	no injury
11	41	"	"	crude petroleum	cr'd. petroleum 8 gal. soap 2 ℔ water 4 gal.	20%	"	"	"	98 %	severely injured

TABLE III.

Experiments with Late Fall Washes. Conducted on the farm of Capt. R. S. Emory, Chestertown, Md

Plats	No. Trees	Kind of trees	Condition of trees	Kind of treatment	Formula	Manner of preparation	Time of application	Time of examinations	Effect on scale	Effect on trees
1	200	pear	badly infested	lime, sulfur and salt	lime 30 lb sulfur 16 lb salt 12 lb water 50 gal.	made in usual way, boiled 1½ hours	Nov. 13, 1902	June 9 and Aug. 20, 1903	very effectual	good
2	200	"	"	"	"	boiled 3 hours	"	"	"	"
3	200	"	"	"	"	all materials put in at once boiled 1¼ hrs	"	"	"	"
4	200	"	"	"	"	boiled 1¼ hrs applied cold	"	"	not as good as above	"
5	200	"	"	lime and sulfur	lime 35 lb sulfur 17 lb water 50 gal.	boiled 1¼ hrs	"	"	very effectual	"
6	200	"	"	Oregon wash	lime 15 lb sulfur 15 lb blue stone 1¼ lb water 50 gal.	boiled 1¼ hrs	"	"	"	"
7	200	"	"	whale oil soap	soap 2 lb to 1 gal. water	soap dissolved in warm water	"	"	not so effectual	fair

TABLE III—Continued.

Experiments with Late Fall Washes. Conducted on the farm of Alfred Loude, Chestertown, Md.

1	30	peach	"	lime, sulfur and salt	lime 30 lb sulfur 16 lb salt 12 lb water 50 gal.	boiled 1¼ hrs	Nov. 23, 1902	June 9 and Aug. 20, 1903	very effectual	good
2	30	"	"	lime and sulfur	lime 30 lb sulfur 16 lb water 50 gal.	boiled 1¼ hrs	"	"	"	"
3	30	"	"	Oregon wash	lime 15 lb sulfur 15 lb blue stone 1¼ lb water 50 gal.	boiled 1½ hrs	"	"	"	"

TABLE IV

Experiments with Spring Washes. Conducted on the farm of Capt R S. Emory, Chestertown, Md.

Plats	No. trees	Kind of trees	Condition of trees	Kind of treatment	Formula	Manner of preparation	Time of application	Time of examination	Effect on scale	Effect on trees
1	200	pears	badly infested	lime, sulfur and salt	lime 30 lb sulfur 16 lb salt 12 lb water 50 gal.	boiled 1¼hrs	March 4 1903	June 9 and Aug 20, 1903	ideal	excellent
2	200	"	"	lime, sulfur and salt	lime 30 lb sulfur 16 lb salt 12 lb water 50 gal.	all materials put in at once boiled 1¼ hrs	March 5 & 6, 1903	"	"	"
3	200	"	"	lime, sulfur and salt	lime 30 lb sulfur 16 lb salt 12 lb water 50 gal.	cold	March 10 1903	"	fairly effectual not as good as above	fair
4	200	"	"	lime and sulfur	lime 30 lb sulfur 16 lb	boiled 1¼ hrs	March 12 1903	"	very effectual	good
5	200	"	"	Oregon wash	lime 15 lb sulfur 15 lb blue stone 1¼ lb water 50 gal.	boiled 1¼ hrs	"	"	"	"

TABLE IV—Continued.

Experiments with Spring Washes. Conducted on the farm of Alfred Louds, Chestertown, Md.

1	30	peach	"	lime, sulfur and salt	lime 30 lb sulfur 16 lb salt 12 lb water 50 gal.	boiled 1½ hrs	March 24, 1903	June 9 and Aug. 20, 1903	ideal	excellent
2	30	"	severely pruned	"	"	"	"	"	"	"
3	30	"	"	whale oil soap	soap 1½ lb water 1 gal.	dissolved in warm water	"	"	ineffectual	poor

EXPERIMENTS WITH EARLY FALL WASHES.

These experiments were undertaken for the purpose of determining what strengths of the insecticides could be used at this season of the year. Therefore solutions of lime, sulphur and salt, whale oil soap, Oregon wash, kerosene emulsion, crude petroleum emulsion, and California summer wash were applied at different strengths (see table II, pages 10 and 11) on badly infested peach trees at Mr. Alfred Loud's place, Chestertown, Md. The solutions were made in the usual manner except as indicated in the table.

It is seen in the table that an application of lime, sulphur and salt full strength and also reduced to 80 gallons will kill the scale but correspondingly hurt the foliage severely. Likewise this is true with whale oil soap at the rate of two and one half pounds and two pounds to the gallon of water and also Oregon wash regular strength and crude petroleum emulsion, but that kerosene emulsion at the rate of 20 per cent can be applied with good results as to killing the scale and it will not hurt the foliage to any appreciable extent. The California summer wash of soap, soda, potash and sulphur seems to be of little use in killing the scale but it does not hurt the foliage.

EXPERIMENTS WITH LATE FALL WASHES.

These experiments consisted of different strengths of whale oil soap and the employment of different methods of making the lime, sulphur and salt wash. Also to observe whether an application of these washes, principally the lime, sulphur and salt in the fall, would be as effective as an application in the spring, when only one treatment is made. These experiments were conducted in a pear orchard at Capt. R. S. Emory's, Chestertown, Md., and in a peach orchard at Mr. Alfred Loud's, Chestertown, Md. In the pear orchard 200 trees were sprayed in each plat. The different methods by which the washes were made is shown in table III, pages 12 and 13. The results of these treatments are indicated in the table and show that the lime, sulphur and salt wash is a very effective treatment even when applied in the fall. The results on the peach trees were equally as good. While with the whale oil soap it was found that there were numerous scales alive at the time of examination and it is therefore not as effective as the lime, sulphur and salt.

EXPERIMENTS WITH SPRING WASHES.

These experiments were conducted in other parts of the above orchards of pear and peach respectively. On the peach trees, the lime, sulphur and salt was used exclusively in different strengths and methods of preparation and the results prove that if made by boiling and applied at this time it is an ideal treatment. Also that the lime and sulphur only is nearly as effective. These same results were obtained from the treatment of the peach trees in Mr. Alfred Loud's orchard. By consulting table IV, pages 14 and 15, it will be seen how the washes were made and the results of the same respectively.

BRIEF CONCLUSIONS TO BE DRAWN FROM THE EXPERIMENTS RECORDED

First. Whale oil soap as a summer treatment can be used as strong as one pound to the gallon, without danger to either apple or peach. This treatment will however only kill the unprotected insects and possibly a few old ones but not sufficient numbers to be of permanent benefit.

Second. Kerosene emulsion, 20 per cent, made with soap seems to have given the most satisfactory results for summer treatment.

Third. Lime-kerosene emulsion seems to be about equally effective in comparison with soap-kerosene emulsion. This used at 20-25 per cent is very effective against the insect. The fine particles of lime in suspension show white when sprayed on the tree and may in this way help the sprayer to see if he has covered all the surface of the tree. The lime does not emulsify quite as readily as the soap and it is a disadvantage in this particular.

Fourth. Oregon wash is very effective in killing the insects but cannot be used in summer even in dilute solutions without injuring the foliage.

Fifth. Crude petroleum emulsion is also very effective against the insect when used at 20-25 per cent strengths. It however burns the foliage when used at 10 per cent. As a summer treatment it cannot be recommended.

Sixth. All the different solutions applied in the early fall, about Sept. 10th., were effective in controlling the scale but all had a bad effect upon the foliage. The 20 per cent kerosene emulsion appears to be the best wash to apply at this time of the year.

Seventh. The lime, sulphur and salt wash applied in the latter part of November or in December was effective in controlling the pest and it is advisable to apply this wash at this time of the year if the trees are badly infested provided another application can be given in the spring.

Eighth. The lime, sulphur and salt wash applied in the spring just before the buds begin to swell proves to be the ideal time and treatment for the pest. Apparently there is little difference in using the lime and sulphur alone or with salt, and boiling all at once, or boiling a part and after a time adding the remainder of the materials or boiling all the materials at once.

Ninth. Whale oil soap, two pounds to the gallon, applied about Nov. 20 is not as effective as lime, sulphur and salt.

LIME, SULPHUR AND SALT WASH.

As stated elsewhere this wash has been relied upon by the orchardists of the Pacific Coast for many years past in the control of the San Jose scale, as, it will be remembered, the scale commenced its ravages about 30 years ago in San Jose Valley, California, and soon became widely disseminated throughout that section of the country. Notwithstanding this the cultivation of deciduous fruits has by no means abated and the western growers as in the past still hold their own in competition with our fruits in the eastern markets. Therefore with the proof that this insecticide is wholly effective in the control of this pest in Maryland there is no reason why its ravages should not be reduced to a minimum in this state.

Another favorable feature as regards this wash is its effect upon fungi. It is said to be a beneficial treatment for most early appearing fungi to some extent but more especially is it effective in controlling the peach leaf curl. In this connection it may be well to state that the addition of copper sulphate dissolved in warm water to the lime and sulphur while it is boiling has been shown in our experiments as well as in other states to somewhat add to its effectiveness in controlling fungi.

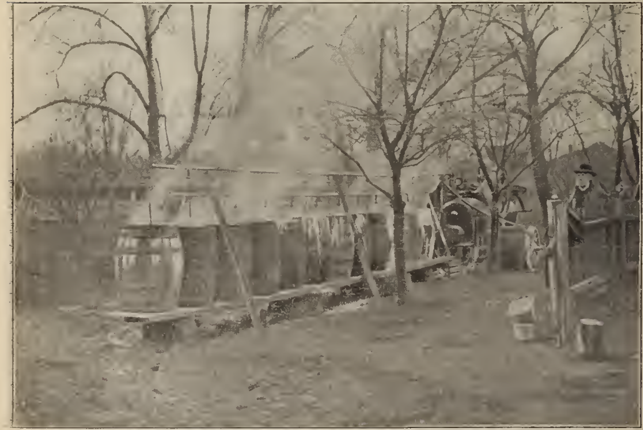

FIG. 3 How the lime, sulfur and salt wash is made on a large scale (After Fsher.)

EFFECT ON THE TREE.

The lime, sulphur and salt wash is a strictly dormant treatment when sprayed all over the tree, but it has been shown by Prof. Wilmon Newell in reporting experiments conducted in summer with this wash, that the normal strength wash can be rubbed or painted on the trunk and large branches of badly infested trees without danger to the tree and will largely retard the increase of the scale. However, in using it during the summer it should not be applied on the foliage or young growth. Since there have been many complaints from injury to trees from the use of the kerosene and crude petroleum it is a pleasure to state that trees will not be affected in any way injuriously by the applicationt of this wash while they are in the dormant state.

TIME OF APPLICATION.

The experiments last fall, testing its effectiveness at that time of the year, showed fairly good results, as the majority of the scales were killed. Where only one application is applied, it is best to wait until late winter or early spring just before the buds begin to swell. An application at this time of the year was found to be the most effective. Where trees are very badly infested it would be advisable to give them two treatments, one in the fall and a second treatment in the early spring. We have witnessed on one or two occasions orchards being sprayed with this wash when the trees were in bloom and no apparent injury done, that is, the orchard produced a fine crop of peaches. However this is a very dangerous procedure and one that should not be practiced.

FORMULA.

Considerable variation is shown in the formulae recommended in the different States. The one which we have used in our experiments is the one generally used in California reduced for 50 gallons of water, and is as follows:

Fresh stone lime, 30 pounds.
Flowers of sulphur, 16 pounds.
Common salt, 12 pounds.
Water to make 50 gallons.

In a recent bulletin issued by the New Jersey Experiment Station, Dr. J. B. Smith recommends the following:

Lime (stone or shell), 50 pounds.
Sulphur (flowers or ground), 50 pounds.
Salt, 50 pounds.
Water, 150 gallons.

According to Profs. Alwood and Phillips of Virginia in a bulletin recently published, the following is recommended:

Lime (unslacked), 30 pounds.
Sulphur (flowers), 30 pounds.
Salt, 10 pounds.
Water, 100 gallons.

There is no doubt that in either of the above formulae and especially in that used by this State there is an excess of lime. This is desired to a certain extent, but there should not be too much lime from the fact that a thick coating of the same may cause it to peal off as does regular white wash at times. Therefore there is no doubt that reducing the quantity of lime to 20 or even 15 pounds to the regular amount of sulphur will give the desired results.

PREPARATION.

There is likewise considerable variations in the methods of combining the materials, and in our experiments it may be seen that we have employed various ways of preparation. As a result we find the following method to be the easiest and best. Boil 15 to 20 gallons of water in an iron pot or hog scalder, now add the proper quantity of stone lime, also the sulphur, which should have been previously mixed with hot water, then allow the whole to boil for at least three quarters of an hour or until the sulphur is thoroughly dissolved producing a clear amber colored solution. The mixture should be stirred and if necessary more water may be

FIG. [illegible]. The manner in which the lime, sulfur and salt wash was made in our experiments at Capt. R. S. Emory's. (Photograph reproduced by courtesy of American Agriculturist.)

added to prevent burning. The salt should be added while the mixture is still boiling. When it has boiled sufficiently add the amount of hot water to make the 50 gallons and carefully strain, through a strainer having about 20 meshes to an inch, into the spray barrel and apply warm. Where the wash is to be made on a large plan and where a steam boiler of any kind is available, it will be much better to cook the wash with steam (see fig. 3). The steam should be conducted into the barrels or vats by means of pipes, which should extend to within a few inches of the bottom of the barrel. Where steam boilers are not available and an orchard of considerable size is to be treated, it will be, in many cases, economical for the orchardist to purchase a small steam boiler. It can be readily taken to the field greatly facilitating the work of preparing the wash and would furnish sufficient steam to cook two or three barrels of the wash at the same time. By the use of a horizontal feed pipe and vertical pipes, extending down into the barrels to within six inches of the bottom, each supplied with a valve, the cooking could be done with comparatively little annoyance. The barrels should be raised on a platform to facilitate the work of drawing off the wash.

There have been reports of orchardists making the wash successfully without boiling, that is, by only using the heat generated by the slacking of the lime in order to make the combination. In this method about twenty gallons of water is boiled, as the lime must be slacked with hot water, so there is no special advantage in this method, as that amount of water has to be boiled and the additional space in the boiler for the quantity of lime, sulphur and salt is very small. Also in this method more lime must be used which would be practically wasted. There are also some differences in recommendations as to adding hot or cold water in reducing the mixture to the regular strength. As a matter of fact when the wash hits the tree it is cold, but the addition of hot water to the concentrated solution will add greatly to the ease with which it may be applied to the tree.

The lime, sulphur and soda wash. It has been the aim of experimenters to secure a wash which can be prepared as easily as possible and to this end the following formula has been used at the New York Geneva Station with some success.

Lime (stone), 33 pounds.
Sulphur (flowers), 17 pounds.
Caustic Soda, 4½ pounds.
Water, 50 gallons.

The lime is slacked with cold water being careful not to drown it, and while the slacking is in progress the amount of sulphur is added gradually. After this add a part of the caustic soda which will cause a violent boiling and before this is over add the remainder which should cause the solution to become somewhat reddish, dilute to 50 gallons and strain into the spray barrel. A good quality of stone lime and caustic soda should be used, in order to generate as much heat as possible. And if hot water is used a good solution may result. While this is rather more expensive than the ordinary wash, it may be useful where there is no means at hand for boiling the mixture. In New York it has proven successful in controlling the scale in some cases while in others it has not. On the whole it is not as good as the boiled wash and costs a little more.

There are other points of interest in regard to the lime, sulphur and salt wash which are now being investigated.

MODE OF APPLICATION.

Any pump that has all the working parts brass and furnishes a constant high pressure may be used, and in general a nozzle that is satisfactory in the application of Bordeaux mixture will also be suitable for the lime, sulphur and salt wash. The "Pomona," "Eclipse" or "Century" barrel-sprayers will be found suitable for the work. Always clean the pump thoroughly after using, by washing out with clear water. The hose and pump are very easily injured if the mixture is allowed to stand in them for any length of time. The wash is somewhat disagreeable to use but one soon becomes accustomed to it. The sprayman should provide himslf with a rubber or oil skin coat, hat and gloves, and many have found a pair of goggles very useful. A slight irritation may arise from contact of the wash with the skin but this might be prevented by greasing or rubbing the exposed parts with vaseline. It is also a good plan to throw a blanket or sack over the horses. The mode of application does not differ in the case of this wash from that of any other spray materials. The main point to be observed is, to be very careful that all the parts of the tree are treated. It is of advantage to have the hose of sufficient length to enable the sprayer to encircle the tree and finish it before leaving. Upon drying, the trees present a whitened appearance very much as if white-washed and it is then very easy to detect any parts that have not been treated. It is also a good plan before spraying to head the trees back as it is difficult to apply the wash on the terminal twigs. This is generally not only beneficial to many classes of fruit trees, but adds much to the good results of the wash. Where trees are very badly infested and some of the terminal twigs dead they should be severely cut back, as this will save a quantity of the wash and will enable the trees to form new tops.

SPRAY PUMPS.

Before buying a spray pump secure catalogues of the following firms and select the one best suited to your needs: Griffith & Turner Co., 205 N. Paca St., Baltimore, Md., who handle pumps for several firms. Gould Manufacturing Co., Seneca Falls, N. Y.; Morrill & Morley, Benton Harbor, Mich.; Deming Co., Salem, Ohio. Hog scalders, steam food cookers, boilers etc., may be secured through the Griffith & Turner Co., Baltimore, Md.; Thomas C. Bassher Co., Baltimore, Md., Crook Horner Co., Baltimore, Md.

In securing a pump be careful to select one that has all the working parts brass. A good pump should have an air chamber, so that a constant high pressure (75 to 100 pounds) may be maintained, and should have a strong mechanical agitator attached. Always clean the pump thoroughly after using.

OPINIONS OF USERS OF LIME, SULPHUR AND SALT WASH.

As evidence of the satisfaction that the lime, sulphur and salt wash has given to those who have applied the same, I herewith quote a few of the original letters, out of the many, which have been received in answer to an inquiry as to the results of the treatment.

Sharpsburg, Md., Oct. 26, 1903.

"My dear Sir:—In controlling the San Jose scale I depend entirely on the lime, sulphur and salt mixture. The results have always been satisfactory. I have some fruit trees that were badly infested with the scale but after a thorough spraying last fall they are now practically clean. Part of my bearing apple orchard was not sprayed last spring on account of the foliage being so early that we did not get through with the work. The apples on this part of the orchard were badly covered with the scale, injuring the fruit vastly much more than the cost of spraying would have amounted to. Of course it is a trouble and considerable expense to spray especially when the trees become large; boiling the mixture and applying it is not pleasant work but my men do not mind it after the first day or two and would just as soon handle the pump and nozzles as any other orchard work.

The lime, sulphur and salt mixture will not only keep the scale under control if applied annually but serves as a fungicide. It practically takes the place of one application of Bordeaux mixture, clears the bark of all moss etc., and leaves the foliage bright and clean. No person owning an orchard infested with scale need become discouraged and destroy his trees. If badly coated it may take two sprayings. Do not use a very fine nozzle; use a good pressure and force the spray against the limbs and branches, (no danger of injuring trees), and the result will justify trouble and expense.

Yours truly,
(signed) Samuel S. Stouffer."

Taylors Island, Md., Sept. 29, 1903.

"My Dear Sir:—In reply to your favor of recent date in reference to treatment of trees for the control of the San Jose scale, will say that while I have tried all the remedies recommended by the College, namely; whale oil soap, crude petroleum, kerosene emulsion etc., with some success, I have never obtained as good results from any of them as I have from the lime sulphur and salt mixture, without doubt it is by far the best remedy for the control of the pest yet recommended. Not only in my own but in other orchards that I have looked over where the remedy has been properly applied the results have been perfectly satisfactory. Such a firm believer am I in the efficiency of this remedy that I do not fear the San Jose scale in the least. It must be borne in mind however that it is essentially necessary to make a thorough spraying to obtain the best results, in fact every part of the tree should be hit with the mixture and where trees are very large they should be given a vigorous pruning and cutting back. Between March 15 and 30 of this year I sprayed 1,000 trees which were badly infested with scale using the formula recommended by the College namely 30 pounds of lime, 15 pounds of sulphur and 12 pounds of stock salt. The trees that were nearly coated over with scale I gave two sprayings about two weeks apart, (this was only necessary however as a safeguard to cover all the tree), this orchard has not only been examined by myself but several professors from the College have examined it with the result that very few live scales could be found. This with other experiments that I have conducted with the lime, sulphur and salt clearly demonstrates to my mind that by thorough spraying with this remedy the San Jose scale can be kept in perfect control. Very truly yours,

(signed) William C. Travers."

Union Bridge Md., Sept., 24, 1903.

"My Dear Sir:—Yours of recent date received, in reply will say the trees which were infested with scale and on which I applied the lime, sulphur and salt wash are in a manner clean of all scale, and that I feel confident that the San Jose scale can be reduced to a minimum by its use.

Respectfully yours.

(signed) H. R. Fuss."

Boonsboro, Md., August 27, 1903.

"My Dear Sir:—Your letter in reference to my experience with the San Jose scale received. I will state that I have it under perfect control by the use of the lime, sulphur and salt wash. In the fall of 1902 it looked to me as if the scale was going to drive me out of the fruit business. During the winter I noticed in the Agricultural papers that the lime, sulphur and salt wash was being used successfully in the west. I gathered confidence enough in it to use it on part of my orchard. The result proved satisfactory so that the following spring I sprayed my entire orchard of 10,000 trees. The weather following the spraying was extremely wet and almost a week of rain and some very hard showers. This however did not affect the results as they were all that could be expected. One orchard eight years old, almost killed by the scale, was severely trimmed and sprayed, now it looks like a young orchard. This wash seems to invigorate the trees gives them a healthful appearance and if properly applied will certainly destroy the scale. Respectfully,

(signed) Caleb Long."

Cambridge, Md., Sept 3, 1903.

"Dear Sir:—Yours of the 2nd. inst., received. Since using the lime, sulphur and salt wash in the spring of 1902, I found it an effective remedy for the control of the San Jose scale. Applied on peach trees this last spring when the buds were showing pink it did no harm; trees bore a full crop. Before using the above wash my experience with 25 per cent kerosene emulsion and whale oil soap was, that they were both failures to check the ravages of the pest. Lime, sulphur and salt is O. K., cheaper and more effective.

Respectfully,

(signed) F. A. Stokes, M. D."

Mapleville, Md., Sept. 8, 1903.

"My Dear Sir:—My experience with the lime, sulphur and salt wash as a remedy for the San Jose scale has been exceedingly encouraging. During the winter of 1900, San Jose scale was discovered in my peach orchard and in the following spring I sprayed with mechanical mixture of coal oil at the rate of 20 per cent. The following year I found that the scale was increasing in my orchard. I again sprayed with coal oil, using the same per cent, just before the buds opened. Examinations later in the year revealed that the scale continued to increase although of course the coal oil had some effect on it for a time, however by this time my orchard was getting in a critical condition and I concluded that something else would have to be done or I would lose all the trees. I noticed in the papers and bulletins a great deal about the lime, sulphur and salt mixture, so I concluded to try it. The results were far ahead of those of previous sprayings. I sprayed about one half of my orchard before the buds opened and the remaining part when the trees were in full bloom. I left about 50 trees unsprayed and it is needless to say that those were in a very bad condition the following fall. That summer I had a fine crop of peaches and found that the condition of my trees had improved. In the spring of this year I again sprayed with the lime, sulphur and salt mixture and at present I have the scale under good control and my trees looking very healthy.

Very respectfully,

(signed) J. E. Fahrney."

Baltimore, Md., Nov. 13, 1903.

"Dear Sir:—Replying to yours in reference to my experience with the lime, sulphur and salt wash, will say in my judgment it is the best spray that we have used.

When I found the scale in my orchard at Rock Hall, Md., I first used whale oil soap with some success, but last March I used the lime, sulphur and salt, and am very well pleased with the results. Trees that I thought were killed from the scale have put out new wood from the crotch and by next spring I will have an entire new head on the old stump; the old dead limbs are still standing but I will take them out this winter. I give the lime, sulphur and salt the credit for this and shall use it extensively next spring. I would advise those who have the scale to use the wash in preference to all others known up to the present time.

Yours truly,

(signed) Allan A. Harris."

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 91. **February, 1904.**

EXPERIMENTS WITH NITROGENOUS FERTILIZERS

"The entire art of manuring is dependent upon a rational and exact application of nitrogen."—*Wagner.*

By H. J. Patterson.

The experiments reported upon in this connection were not simply soil tests conducted for the object of determining if a particular piece of land needed applications of nitrogen, and if so how much; but the idea in mind in planning and carrying out the work was to study some of the underlying principles connected with the use of nitrogenous fertilizers of different kinds and to compare the principal sources of nitrogen which are commonly found on the market. It is hoped that the results which have been and will be obtained in connection with this study will in the main be just as applicable in one part of Maryland as another and in fact have a broad and general value in all sections where commercial fertilizers are being used.

Before taking in detail the plans of the experiments conducted and the results obtained up there will be given a brief description of the different sources of nitrogen available to farmers and a few words as to the history of its use in agriculture as far as known.

EARLY USE OF NITROGENOUS FERTILIZERS.

The first writers and investigators upon the subject of plants and their relation to the fertility of the soil seemed to content themselves with pointing out the relations between the mineral matters of the soil and plants and for a time thought that it was only necessary to supply to soils these essential mineral substances in order to increase their productive capacity.

The results set forth by Saussure (1804), Sir Humphrey Davy, (1814), Springel (1839) and indeed the earlier researches of Liebig seemed to explain quite satisfactorily that the theory of manuring depended entirely upon furnishing to the plant those elements found in the ash.

The conclusion drawn by these early investigators was no doubt largely due to the character of land upon which the tests were conducted.

Among some of the early investigations conducted at Rothamsted it was pointed out for the first time in a clear and convincing manner that the ash constituents of plants did not furnish all that was requisite. The Rothamsted experiments showed that yard manure produced a marked increase in yields while the ash from a like quantity of manure produced no increase. It was in connection with this source of investigations that the value of nitrogen and the application of nitrogenous manure was pointed out for the first time.

While many manures and other materials containing nitrogen had been used for many years, probably from almost the earliest days of agriculture, for we have record that the early American settlers found it a practice with the Indians to put fish in the corn hills; yet all of the use of such materials was done without any real knowledge of nitrogen and its relation to plant growth and without attributing their value to any particular ingredient. Thus it is seen that the early history surrounding the use of nitrogenous fertilizers is even more indefinite than that of lime potash and phosphoric acid and that nitrogen like many things came into general use without its virtues being understood and that these together with the reasons for its use were left to be explained later.

NITROGEN ESSENTIAL TO PLANTS.

Nitrogen is one of the most important elements of plant food for it is found not only in every part of plants but the compounds of which it forms a part contributes largely to the value of plants for food purposes. Nitrogen exerts a very marked influence on the growth of plants and either a deficiency or abundant supply will be manifest in a few hours, in the vigor of the plant. This condition of itself would indicate that this element performed some very important function in plant nutrition.

LOSS OF NITROGEN FROM THE SOIL.

Nitogen is the only one of the essential plant foods that is subject, to any extent, to actual loss aside from what is removed by crops.

Nitrogen compounds particularly the nitrates are very soluble in water and hence there is more or less loss of these valuable materials by leaching into the drainage waters.

The researches of Way and others have shown that ammonia compounds are to a considerable extent retained by soils, only traces of ammonia being found in drainage water: nitrates, however, are not retained in this manner, and, unless they are appropriated by plants, are easily washed out of the soil by rains and lost. Owing to the readiness with which plant roots absorb nitrates, there is practically no loss in soils which are covered by vegetation; on the other hand, the loss from a bare fallow is sometimes enormous. The lysimeter observations at the New York Agricultural Experiment Station showed a loss at the rate of over 200 pounds of nitrogen, in the form of nitrates, per acre each year from the lysimeter, where the soil was kept free from vegetation, while from the lysimeters having the soil covered with grass, the loss was less than one pound per acre. Although these results do not necessarily indicate what occurs in cultivated fields, they are certainly suggestive, and with other experiments, sustain the practice of keeping agricultural land constantly occupied by some growing plants.

In addition to the nitrogen removed from the soil by crops and by drainage, a little nitrogen gas escapes into the air, it being set free by the oxidation or decay of organic matter. The total amount of this loss varies with climate, with the kind of crop and with the method of culture. Tillage increases it, and it is comparatively small in wild land and in permanent pasture.

Nature replaces these losses to the soil in the organic matter which decays upon its surface, in the nitric acid and ammonia dissolved in rain and dew, and lastly, in some unknown way, from the free nitrogen of the air, by converting it into compounds suitable for plant nutrition. But under the common conditions of agriculture, the losses almost invariable exceed the supply and after a time the available nitrogen is reduced to a point where profitable crops cannot be grown without the use of nitrogenous manures derived from some other source than the soils themselves.

The quantity of nitrogen received by the soil in rainwater has been determined in numerous places and found to vary greatly with locality. The Kansas Experiment Station reports an average rain-fall of 29 inches for four years, containing 3.44 lbs. of nitrogen per acre per year. At Rothamsted, England, 3.74 lbs. of nitrogen per acre was thus annually obtained; on the continent of Europe, the quantity was 5.23 lbs. and at Tokio, Japan, only 2.8 lbs. This source of natural manuring was equivalent to applications of nitrate of soda per acre as follows: Kansas, 20.9 lbs; England, 22.5 lbs; Europe, 31.4 lbs. and Japan, 16.8 lbs., annually.

GENERAL CONDITIONS INDICATING THE NEED OF NITROGEN.

As a rule when plants are pale green or yellow in color or when there is a small growth of leaf or stalk and other conditions are favorable, the indications point to a lack of nitrogen. However a bright green color and a vigorous growth of leaf and stalk does not always indicate that more nitrogen could not be used to advantage. An excessive growth of leaf or stalk accompanied by an imperfect flower and fruit or grain development indicates that there is an abundance of nitrogen for the needs of the crop under existing circumstances and that more phosphoric acid or potash or both are necessary in order to provide a balanced ration. In such cases if the phosphoric acid and potash were supplied in sufficient quantities there is even a probability that more nitrogen could be utilized to advantage.

QUANTITY OF NITROGEN ANNUALLY REMOVED FROM MARYLAND FARMS.

In order to convey some idea of the great drain of nitrogen from Maryland the figures in Table I. have been compiled showing the amount which is removed by the staple crops. Though these figures may seem large yet they represent only a part of the nitrogen that is annually needed by crops. The amount removed by over Seven Million dollars worth of truck crops, small fruits, orchard fruits and etc., annually sold is not accounted for in the table, or the very considerable amount removed by the live stock, poultry, eggs and milk produced. The total amount of nitrogen removed as exhibited by the figures in the table (79,230,104 pounds) would require 247,594 tons of standard nitrate of soda or its equivalent to replace it. This would mean an expenditure of nearly ten million dollars for nitrogen which when added to the two million dollars for potash and the one million dollars for phosphoric acid make a grand total of thirteen million dollars worth of essential plant foods used by the staple crops.

TABLE I.

Approximate Quantity of Nitrogen used by the Staple Crops grown in Maryland.

Crop	Acres	Pounds of Crop	Per cent Nitrogen	Pounds of Nitrogen
Corn grain	658,010	1.107.924.560	1.82	20 164,227
Corn fodder	"	2,215,849,120	1.04	23.045,831
Wheat	634,446	580.308,000	2.36	13,695,269
Wheat Straw	"	986.523,600	0.59	5,820,489
Oats	44,625	35,505.920	2.06	731,422
Oat Straw	"	60.360,000	0.62	374,232
Barley	1,515	2,042.880	1.51	30.847
Barley straw	"	3 342 140	1.31	43,782
Rye	21,621	15.654,800	.76	275,524
Rye straw	"	26,613,160	0.46	122,421
Buckwheat	8.047	5.565.600	1.44	80.145
Buckwheat straw	"	9.461,520	0.49	46,361
Hay and forage	374.848	1,014,084,000	1.41	14,298,584
Tobacco	42,911	24,589,480	0.67	164,750
Potatoes	32,941	160,152,420	0.21	336.320
Total				79.230.104

THE ORIGIN AND SUPPLY OF NITROGEN IN SOILS.

Nitrogen unlike the mineral constituents of soils does not have its origin from the decomposition of rocks but it has been derived from some outside source. The nitrogen of soils has been derived largely from previous vegetation; though some has been brought to the soil through rain water. The supply of nitrogen in the most fertile and best cultivated land has had its origin through the agency of the plants growing upon it, through absorption from the atmosphere by means of rain and dews or through artificial applications or a combination of these agencies.

Very wide differences exist in the amount of nitrogen in different soils; but will be found to range in cultivated soils from as little as 0.005 per cent in some sandy soils to as much as three per cent in peat soils. Fertile soils generally range from one tenth to three tenths of one per cent. Most of the nitrogen is generally found in the surface foot of soil and the quantity rapidly diminishes downward. In most cultivated soils there is generally found much less nitrogen than potash and phosphoric acid. Nitrogen is the only plant food which is much subject to loss by leaching and as it is the most expensive to buy it is of paramount importance that methods for its conservation are well looked after.

CONDITIONS OF THE NITROGEN OF SOILS.

The nitrogen of all fertile soils exist in both organic and inorganic combinations. In most soils there will be found some nitrogen in organic compounds, some in ammonia compounds and some as nitrates.

It is only the nitrogen in forms of nitrates that is available to plants. The nitrogen which exists in organic and ammonium combinations must first be converted into a nitrate before it will be useful to growing crops.

The organic nitrogen which exists in a soil or which is supplied to it by means of stable manure or some of the organic sources of commercial fertilizers must first undergo the ordinary decomposition or putrification which is effected by a bacteria and be converted into an ammonium compound. After this has taken place the conditions are favorable for what is termed nitrification or the conversion of the nitrogen to a nitrate which will be available to plants for food.

NITRIFICATION.

It is not the intention in this paper to discuss this subject at any length as it is entirely too large to handle thoroughly, but it is believed that a few statements upon the subject may be helpful to some in a more rational use of nirogenous fertilizers.

As far as known at present it is believed that nitrification is caused by two distinct organisms. The work of the first is to convert the ammonium compounds to nitrous acid or a nitrite and is known as the *nitrous ferment.* The work of this nitrous ferment is immediately followed by the conversion of the nitrous into nitric acid or a nitrate by means of what is known as the *Nitric Ferment.*

These ferments or bacteria are very small plants and while they generally exist in vast numbers yet they cannot be seen without the aid of powerful magnifying glasses or microscopes. Nitrification does not take place under etxreme conditions but proceeds best when it is neither too warm or too cold, neither too dry or too wet. Nitrification stops when the temperature is below 35 degrees or above 130 degrees F. It is favored by a fair amount of organic matter yet there is a possibility of this being in excess but this condition is not commonly met with in ordinary farm practice. It takes best in soils which are feebly alkaline and hence is favored by the judicious use of lime. Oxygen and moisture are necessary; hence the soil should be properly drained so as to supply these requirements to advantage.

SOURCE OF NITROGEN.

Nitrogen has always been the most costly element in artificial fertilizers, and at the same time, the element which is most often deficient in cultivated soils and also the easiest to lose by carelessness and waste. These conditions in themselves make a study of this element of interest and profit and it becomes doubly so since there are systems of farming which make it possible to supply a considerable amount of this element without purchase. Motives of economy have forced consumers to give more attention to saving and supplying nitrogen from home resources and buying less. Manufacturers have had a tendency to lessen the percentage of nitrogen or ammonia in their mixed fertilizers for the general market, in order to reduce the price on these goods.

A consideration of these facts produce an appreciation of the force of Prof. Paul Wagner's statement that "The entire art of manuring is dependent upon a rational and exact application of Nitrogen."

Nitrogen occurs in nature in the following forms:

(1) As a constituent of *air*, as free nitrogen.
(2) In the form of *ammonia*.
(3) In the form of *nitric acid* and *nitrates*.
(4) In various forms in plants and animals or *organic sources*.

1. *Nitrogen in air.* Nitrogen exists in the air uncombined with any other element or in other words in a free state. It is an inert, tasteless, odorless, colorless gas, constituting approximately four-fifths of the bulk of our atmosphere. The other one-fifth is approximately oxygen. Most cultivated plants cannot use the free nitrogen of the atmosphere directly but the legumes (clover, peas, beans, etc), are enabled to use it indirectly through the agency of organisms which are found on their roots. Whenever nitrogen is mentioned in connection with fertilizers or fertilizer analyses, the gas, as such is referred to. The chemical designation or symbol for nitrogen is N.

2. *Nitrogen in ammonia.* Ammonia is formed by a chemical union of one part of Nitrogen (N) with three parts of hydrogen (H) and described by H_3N. The H_3N is a gas which dissolves in or unites very easily with water and forms ammonium hydrate (H_4NOH) which is the common "ammonia water," "aqua ammonia" or "Spirits of Hartshorn" of commerce. Ammonia is formed when vegetable and animal substances containing nitrogen decompose or when they are subjected to dry distillation. Thus most of the ammonia of commerce is made as a bye product in the manufacture of illuminating gas from coal or in making coke. Ammonia unites with different acids and forms salts somewhat as metals do. These salts are called *Ammonium Salts*. These salts are generally white, neutral, odorless, and crystaline in appearance much like common salt. Thus ammonia combined with sulphuric acid forms *ammonium* sulphate commonly called sulphate of ammonia which is the only ammonium compound commonly met with in the fertilizer trade. Ammonia combined with hydrochloric acid forms ammonium chloride, some times called muriate of ammonia also known as sal ammoniac. Sal ammoniac is the salt used for dissolving in the water commonly used in telephone batteries.

There is a very small amount of ammonia in the atmosphere (estimated at 1 pound in 26,0000,00 cu. yds. of air) and some of this finds its way to the soil through dews and rains. Some plants have the power to absorb ammonia directly from the air through their leaves and some plants can use the ammonium salts through the soil directly, but for the most part the ammonium compounds are changed into nitrates in the soil before being used by plants.

Sulphate of Ammonia. This is the only ammonium compound which is much used or found in the fertilizer trade. When pure it is a white crystaline, odorless, salt, but as found in the fertilizer trade is often much colored and has some odor from the impurities it contains. Most of the sulphate of ammonia of commerce is obtained as a bye product in the manufacture of illuminating gas and from coke works. It is made by absorbing the ammonia gas in sulphuric acid, then evaporating the excess of water until a dry salt is obtained. It contains about 20 per cent of nitrogen.

When ammonia is referred to in an analysis of a fertilizer it generally means the percentage of H_3N. In most states the trade prefers quoting ammonia instead of nitrogen. This is probably due to the force of early habit as it was easier to explain to farmers what ammonia or hartshorn was than nitrogen from the fact that every farmer was already familiar with Hartshorn due to its odor in horse stables and manure piles. By stating the analysis as ammonia the percentage is higher than it would be stated as nitrogen.

To convert any stated percentage of ammonia to its equivalent of nitrogen, the rule is to divide the former by 17 and multiply the quotient by 14. To make the reverse computation divide the stated per cent of nitrogen by 14 and multiply by 17, the result is the equivalent ammonia.

3. *Nitrogen in Nitrates.* When two parts or equivalents of the gas Nitrogen (N) is combined with five parts or equivalents of oxygen (O) it forms nitric acid or nitric anhydride and is represented by the symbol N_2O_5. This is what is meant when nitric acid is referred to in a chemical analysis. Commercial *nitric acid* or *aqua fortis,* is a combination of pure nitric acid with water (H_2O) and forms what is described chemically by HNO_3. Nitrates are formed by a combination of nitric acid with a metal or base or in other words by the replacing of the hydrogen of HNO_3 with a base such as sodium, potassium or lime, and thus making a salt such as sodium nitrate (N_aNO_3) or as commonly called nitrate of soda.

The largest part of the nitrogen obtained by most plants is taken up by their roots from the soil as nitrates. Most of the nitrates used by plants are formed from ammonium compounds and organic substances in the soil process called nitrification. Thus it will be noted that nitrates are the most available form of nitrogen for most plants as they can be directly and readily taken up and used by plants as food.

Nitrate of Soda. Also known as "chili salpeter" is the nitrate commonly found on the market for fertilizing purposes. It is found in large deposits which have been formed in the rainless regions of Chili and Peru. The following is the description of the nitrate deposits as given by Dr. John A. Myers in American Chemical Journal, Vol. 21 (1899) p 445.

"At present, the entire supply of sodium nitrate comes from Chili, although it is found in some other parts of the world, but not in sufficient quantities to compete in the markets of the world. The portion of the west coast of Chili, where it is found, between latitudes 19 degrees 12 minutes south, and 25 degrees 45 minutes south, extends over a length of approximately 260 geographical miles. The principal deposits are found in the provinces of Tarapaca and Antofagasta, in Chili and the center of trade is Iquique. It exists in a long narrow strip averaging about two and one-half miles in width extending along the eastern slope of the Coast Range at an average distance of perhaps fourteen miles from the ocean but in a number of cases it is probably as much as forty miles from the coast. The region where it is found is a rainless desert absolutely devoid of vegetation. The nitrate beds exist at a height of from 3000 to 5000 feet above sea-level and extend down towards the valley of Tamagruel. This accumulation in the course of ages was elevated. One of the evidences of this lies in the fact that the remains of seaweed are found in the nitrate deposits. The beds are 500 or 600 feet above the valley of Tamagruel and extend down toward it decreasing in value as they approach it until they finally disappear upon reaching it. The beds exist under the following conditions and skilled prospectors can generally locate the beds with considerable certainty by the surface indications:

The surface for a depth of approximately ten inches is covered with a layer of fine loose sand; under the sand is found a layer of amorphous porphyry, feldspar, sodium chloride and other mineral matter cemented together by gypsum into a compact mass varying in thickness from six to ten feet. This is called *costra* or crust. Under this crust is found the *caliche*, or impure sodium nitrate, varying in thickness from a foot and a half up to about twelve feet. The *caliche* occurs in a great variety of colors, as yellowish white, orange, blue-gray and dirt color. This deposit is a regular stratum, with all the appearances of a rock formation firmly, cemented together, and is displaced from its natural position, by blasting. The system of blasting is peculiar in this, that they drill a hole through the crust and through the *caliche*, down to the clay surface beneath, large enough to admit a boy, who is let down and excavates the clay under the *caliche*, so that the blast can be placed under the material to be broken up, the object being to thrust up as large a mass of *caliche* as possible. This is then broken up by the tools of the workmen into chunks the size of an orange, and the impurities as carefully removed as possible by the process of selection. This crude material is then transported to the works where it is run through a crusher, and dissolved in hot water. The better quality of *caliche* contains from forty to fifty per cent. of sodium nitrate. The average quality from thirty to forty per cent. of sodium nitrate, and the poorest quality that is worked, from seventeen to thirty per cent. of sodium nitrate. The best quality of *caliche* runs as follows.

	Per cent.
Sodium nitrate	50
Sodium chloride	26
Sodium sulphate	6
Magnesium sulphate	3
Insoluble	14
Sodium iodate Sodium nitrate Magnesium chloride Potassium chloride Magnesium nitrate	1
	100

The nitrogen in nitrate of soda being already in the form required by plants, possesses a divided advantage over the various forms of organic nitrogen in that its action does not depend upon the decomposition which such materials must undergo, or the conditions upon which such decompositions depend. Nitrate of soda is quickly dissolved in water and is immediately available to plants and as it forms no combination in the soil which are less soluble it soon becomes diffused or distributed through the soil and rapidly reaches every point where it may be utilized. This characteristic however subjects this valuable material to loss by being leached or washed out of the soil by excessive rains and suggests the desirability of applying the nitrate in small quantities as needed by the crop.

Nitrate of Potash. This is the true "Saltpeter" of commerce. It is rich in both nitrogen and potash and would be a valuable source of plant food were it not for the fact that its supply is limited and it has many other uses in the arts which cause the price to be too high for fertilizing purposes. This was a favorite and important source of nitrogen before the discovery of the deposits of nitrate of soda and of potash before the discovery of the Strassfurt potash salts. Most of the nitrate of potash is found in caves; but in recent years there has been numerous reports of the discovery of extensive deposits in Africa, but up to this time not enough has reached the markets to materially affect the price.

Nitrate of potash possesses the same general characteristics as nitrate of soda. It contains about three per cent less nitrogen than nitrate of soda but contains about 45 per cent of potash which is available to plants; hence is a very concentrated fertilizer.

(4) *Organic sources of Nitrogen.* This form of nitrogen is supplied in animal and vegetable products in which the nitrogen exists in combination with hydrogen, oxygen and carbon. Some of the substances for example are the casein or curd of milk, the gluten or gummy portion of wheat, the fibrin of blood and the white of egg. When vegetable and animal products decompose the nitrogen is first changed into ammonia and then under proper conditions of warmth, moisture and access of air, into nitric acid and nitrates.

Animal sources of Nitrogen constitute not only the chief organic source but probably the largest proportion of nitrogen occurring in commercial fertilizers are of animal derivation. This material comes mainly from slaughter houses rendering works and fish oil factories. The following are the most commonly used; Azotine or ammonite, bone meal, dried blood, dried fish, fish scrap, garbage tankage, hair, hoof meal, horn dust, leather meal, lobster shells, meat scrap, nitrogenous guanos, tankage and wool waste.

Azotine or Ammonite are rather meaningless names given to dried and ground meat, tendons, membranes and etc., from which fat has been extracted at pork packing and rendering houses. It usually contains about 10 per cent of nitrogen and 3 or 4 per cent of phosphoric acid.

Bone Meal properly belongs to phosphatic rather than nitrogenous fertilizers, yet as this material is used extensively as a source of phosphoric acid and at the same time furnishes 3 to 5 per cent of nitrogen it assumes considerable importance as a source of nitrogen.

Dried Blood is derived from the blood of slaughtered animals and is prepared for market by evaporating, drying and grinding. The color varies with the degree of heat to which it has been subjected in drying, ranging from red to black. The amount of nitrogen varies from 6 to 15 per cent. It also contains some phosphoric acid.

Dried fish, Fish scrap and ground fish consists of the refuse from fish oil works and fish canning factories. These materials are placed on the market in a dried and finely ground condition. The refuse from the oil works is quite uniform in composition, containing 7 to 8 per cent nitrogen and about 7 to 8 per cent phosphoric acid. The product from canning factories consists of skins and bones and etc., of fish and is variable in composition.

Garbage Tankage is material obtained by drying city garbage and is a low grade fertilizing material as its composition and other characteristics varies greatly but always contains a low percentage of plant food. It is relatively richest in nitrogen but also contains phosphoric acid and potash.

Hair and Wool Waste is obtained from slaughter houses and is more or less mixed with blood and other forms of animal refuse. Hair contains about 15 per cent nitrogen and wool about 5 per cent. These are considered low in value as sources of nitrogen, as they decompose and become available to plants very slowly. In recent years these materials have been mixed with rock and treated with acid with the idea that this process would render the nitrogen more readily available.

Hoof Meal and Horn Dust are by-products containing 10 to 15 per cent Nitrogen and about 2 per cent phosphoric acid. In their natural state they decompose slowly hence are not valuable sources of nitrogen, recently however they have been treated with acid in the process of dissolving phosphates in order to make the nitrogen available.

Leather Scraps and Leather Meal are the waste products of various factories. This material is dried or roasted and then it can be finely ground. The meal has much the appearance of dried blood and is used to some extent for adulterating this material. It decomposes slowly and hence is not considered valuable as a source of nitrogen which has led to its being treated with acid in the process of making dissolved phosphates, the same as are hair, wool waste and etc.

Lobster Shells accumulate in considerable quantities at lobster canning factories and they are now being used as a source of nitrogen in fertilizers. The finely ground shells are used considerably to adulterate finely ground bone. They contain about 4½ per cent of nitrogen.

Meat Scrap is quite rich in nitrogen. It is gradually dried and finely ground and mixed with some of the grades of tankage, unless it is sold in various forms as chicken food.

Guanos.—Nitrogenous guanos are found in warm dry regions and at one time formed one of the principal fertilizers on the market. For a time they almost disappeared but now new deposits have been developed and considerable is found in the markets. In this form nitrogen-bearing manures first appeared in the commerce of this country. Maryland was the pioneer State in the use of guanos. They were imported at Baltimore, and applied to crops by farmers in this State in 1832, and the years immediately following. This was sometime before crushed bones were used as fertilizers to an equal extent, and several years before guanos had any recognized place in the commerce or agriculture of England. Guano, in the original language of Peru, signifies dung, and was spelled *huano* by the Spaniards. It was used and gave fertility to the sandy coasts of Peru for ages, before it was known elsewhere. An old Peruvian proverb says: "Huano, though no Saint, works many miracles." During the government of the native Incas, severe penal laws protected the sea-fowl which deposited this manure on the granite islands off the coast of Peru. There the Baron von Humboldt first observed the deposits of guano and their uses in 1804, and subsequently made it known to Europeans. For many years after Peruvian guano was a common article of commerce; the best quality was brought from the Chincha islands, three in number, each five or six miles in circumference, and about half a mile apart. There the deposits lay from 80 to 200 feet in thickness, varying in color from a light to a dark shade of brown. The guano which came from these and other islands of the Pacific, had been comparatively free from losses by rain and leaching, and were rich in nitrogen, phosphoric acid and potash, forming a "complete" commercial fertilizer. But great as were these deposits the supply of nitrogenous guanos has been practically exhausted for some time. Guanos valuable for the nitrogen they contain are now rather exceptional in the markets. The materials bearing this name, although having the same general origin, come mostly from localities having very different climates, and have lost the nitrogen and potash originally contained, or most of it. They are therefore more properly called phosphatic guanos, and should be considered under that head.

Tankage is slaughter house refuse made up of miscellaneous materials, such as the stomach and entrails and their contents, bones, tendos, hair, hides, hoofs, and etc. Two kinds of tankage are found on the market. One kind is known as Concentrated tankage, and is made by evaporating some of the fluids rich in nitrogen obtained in extraction processes. This kind of tankage contains 10 to 14 per cent nitrogen and very little phosphoric acid. The second is known as bone or crushed tankage , and consists of varying quantities of different parts of animals and slaughter house refuse which is otherwise unsalable. This tankage varies greatly in composition ranging in nitrogen from 4 to 10 per cent and in phosphoric acid 3 to 12 per cent. Immense quantities of tankage are used in the manufacture of commercial fertilizers.

VEGETABLE SOURCES OF NITROGEN.

Nitrogen may be supplied by many forms of vegetable matter, but as most of the substances have more value for other purposes, there are only a few that have much direct importance in the fertilizer trade, chief of which are Cotton seed meal, Castor-Pomace and tobacco stems.

Cotton seed meal is not appreciated in most parts of the country as it should be. Its manurial value is very great. It may be called a "complete" fertilizer, because it contains all the important elements of plant food, and all are in forms to be readily used by plants. The whole seed as ordinarily separated from the lint or fiber, may be regarded as containing on an average, per ton, one thousand pounds of hulls, and one thousand pounds of kernels. From the kernels, about three hundred pounds of oil may be obtained, leaving seven hundred pounds of meal. The whole seed, hulls and meal, have the following average chemical composition, in part;

TABLE II.

Average Composition of Nitrogenous Fertilizers.

Cotton Seed Analysis in Mississippi	Nitrogen		Phosphoric Acid		Potash	
	Per Cent	Lbs. per Ton	Per Cent	Lbs. per Ton	Per Cent	Lbs. per Ton
Whole seed.	2.8	56	1.4	28	1.14	22.8
Hulls	0.7	14	0.7	14	0.88	17.6
Meal........................	7.0	140	3.0	60	2.00	40.0

As yet the whole cotton seed can be found in the cotton producing states, and the hulls where cotton-oil mills are located. But the meal, pressed, dried and ground after the oil is removed, is a common article of trade. It is valued highly by those who are acquainted with it, as a food for livestock, especially cattle. It is largely used in the South for fertilizing purposes, and forms a part of most of the complete commercial fertilizers found in the Southern trade.

Castor-Pomace is a bye-product of the factories making oil from the castor bean, and so much like cotton-seed meal that no further description is necessary. It is usually not quite as rich in plant food. The market supply is comparatively limited.

Tobacco stem dust or ground Tobacco Stems. This is another refuse material of vegetable origin, which enters quite largely into compound fertilizers and is handled in considerable quantity in the Baltimore market. It contains from 2 to 2½ per cent. of nitrogen and from 6 to 7 per cent. potash, and should have a place in the list of potassic fertilizers.

The following table gives a summary of the approximate quantities of nitrogen contained in various fertilizing materials:

TABLE III.

Materials Containing Nitrogen	Nitrogen		Phosphoric acid		Potash	
	Per Cent	Pounds per ton	Per Cent	Pounds per ton	Per Cent	Pounds per ton
(1) MINERAL MATERIALS						900
Nitrate of potash	13.5	270			45.0	
Nitrate of soda	15.5	310				
Sulphate of ammonia	20.0	400				
(2) ANIMAL MATERIALS						
Azotine or ammonite	11.0	220	3.4	68		
Bone meal	4.5	90	22.5	450		
Dried blood	12.0	240	1.9	38		
Dried fish	7.5	150	8.0	160	0.5	10
Hair	15.0	300				
Hoof and hair dust	12.5	250	2.3	46		
Leather refuse	7.5	150				
Lobster shells	4.5	90	3.5	70		
Meat scraps	11.5	230	2.0	40		
Nitrogenous guanos	7.5	150				
Tankage (concentrated)	11.5	230				
Tankage (bone or crushed)	7.0	140	8.0	160		
Tankage (garbage)	1.5	30				
Hoof waste	5.5	110				
(3) VEGETABLE MATERIALS						
Cotton seed meal	6.5	130	3.0	60	2.0	40
Castor bean pomace	5.5	110	2.0	40	1.0	20
Tobacco stems	2.0	40	0.6	12	6.0	120
Mixed stable manure	0.5	10	0.2	4	0.6	12

THE USE OF THE FREE NITROGEN OF THE ATMOSPHERE BY PLANTS-

As has already been stated, about four-fifths of the atmosphere is composed of nitrogen and while it is not within the province of this bulletin to give a full discussion of this subject yet it is a matter of so much agricultural importance that a few words as to the present state of our knowledge of the subject are necessary. It has been proved beyond a doubt that the family of plants known as legumes, which comprises the clover, peas, beans, etc., have the power to use the free nitrogen of the atmosphere through the agency of organisms or bacteria which grow on their roots and produce what is commonly known as nodules or tubercules. From the earliest time of which we have any record in agricultural writing there was special value attached to this family of plants as soil improvers and the nodules on their roots had been noticed for many years before their true nature was discovered. At first these nodules were supposed to be evidence of a diseased condition of the plant and it was not until about fifteen years ago that it was shown conclusively that they could convert the free nitrogen of the atmosphere into a form which could be used by higher orders of plants.

Experiments so far seem to show that the use which legumes can make of the free atmespheric nitrogen is in proportion to the development of the tubercules, also that the relative amount of nitrogen derived from the atmosphere is greater on a poor than a rich soil or in other words utilization of atmospheric nitrogen by legumes is in proportion to the poverty of the soil.

It is also claimed by some investigators that root tubercules exert no influence in nitrogen assimilation when there is an abundance of available nitrogen in the soil.

It has been shown conclusively that all soils do not seem to be inoculated with the proper bacteria for producing the tubercules on the roots of legumes but the successive growing of the same legume on the same land will usually bring about a condition where they will be found in abundance and be accompanied by a decided increase in the yield of that crop.

ARE THERE DIFFERENT KINDS OF ROOT TUBERCLE ORGANISMS.

This is a question which has been much discussed, and have formed the subject of many investigations, but the results, so far, have not given a positive answer. Some authorities hold that there are separate races or kinds for each species or group of nearly allied species of plants. Other authorities claim that it is not a different bacteria but that the bacteria changes in form and virulence owing to the host or media in which it grows.

Be this question as it may the fact confronts the practical farmer that the same soil will not grow tubercules with equal facility on all the legumes, and that it is necessary to have some sort of inoculation before satisfactory crops of some things can be grown. This is practically true of alfalfa and vetch in many parts of Maryland, and of cow peas in a few sections.

ARTIFICIAL INOCULATION,

The most successful attempts at artificial inoculation have been by the use of soil which is known to contain the proper organisms. The use of the soil has generally proved satisfactory, yet it has been disappointing in some cases. This has probably been due to the want of proper care of the soil and permitting it to dry out too much in transit, but no doubt in some cases the land which was being inoculated did not afford the proper conditions or media for the development of the organisms. It requires at least 500 pounds of soil to properly inoculate one acre. It is not always easy to obtain the amount of soil desired, and the transportation is expensive. These facts seems to limit the use of soil. Then too there are dangers of transmitting plant diseases which should be guarded against.

There have been a number of efforts made to prepare the bacteria in a form which could be easily handled and sent from place to place like yeast for bread; but none of these have proven entirely practical and satisfactory up to this time. The past year the United States Department of Agriculture have conducted numerous experiments upon this question and the results so far seem to point to a satisfactory solution.

EXPERIMENTS CONDUCTED WITH NITROGENOUS FERTILIZERS.

Description of Tests and Land.

The principal object in making these studies of nitrogenous fertilizers, was to try and solve some of the general principles surrounding their use and to make a test of the various sources of Nitrogen commonly met in the trade.

These experiments were started in 1897, and up to this time six crops have been removed. The land used for these tests is located north of the Experiment Station Buildings, and in the same field with the Phosphoric Acid and Potash series of plots. The land is a medium stiff clay loam, quite uniform in quality, fairly level and yet has a pretty good drainage.

The previous cropping of this land, so far as known, was as follows: In 1888 there was a poor stand of grass and weeds. This was plowed down and seeded to wheat in the fall. Timothy and clover were seeded in the wheat. The wheat harvested in 1889 gave about eight and one-half bushels per acre. The land was in grass in 1890-91 and in 1892 in corn. In the spring of 1893, the corn stubble was harrowed and seeded to Crimson Clover. This was turned under and seeded to wheat in the fall. Wheat cut in 1894, timothy and clover were seeded in the wheat. In 1895 and 1896 the grass in this field was cut for hay. The sod was plowed in November, 1896, and the Nitrogen plots laid out the following spring.

The following is the program of the experiments conducted:

TABLE 4.

Program of Nitrogen Experiments.

(Plots one tenth of an acre each.)

The quality of material applied was such as to give each plot at the rate of thirty-two (32) pounds of nitrogen (N) per acre.

Plot No. Kinds of Fertilizer.

1.—Nitrate of soda, (applied at time of planting crop.)
2.—Nitrate of soda, and Lime,* (applied at time of planting crop).
3.—Nitrate of soda (applied at time of most active growth.)
4.—Nitrate of soda (one-half applied at time of planting crop, one-half applied at time of most active growth.)
5.—No Nitrogen.
6.—Nitrate of soda and Sulphate of potash.
7. Nitrate of potash.
8.—Sulphate of ammonia.
9. Sulphate of ammonia and lime.*
10. Nothing.
11.—Nothing.
12.—Dried blood.
13. Raw leather waste.
14.—Dissolved leather waste.
15.—Nothing.
16.—Nothing.
17.—Raw hair waste.
18.—Dissolved hair waste.
19. Bone tankage.
20.—Dried fish.
21. Nothing.
22. Cottonseed meal.
23.—Stable manure.
24.—Nothing.
25.—Lime.*
26.—Nothing.
27. Lime.
28. Nothing.

The experiments outlined in the schedule in table 4 can be classified under the following heads:

1.—Comparison of different times of applying Nitrate of Soda.
2. Comparison of Nitrate of Soda and Sulphate of Ammonia.
3. Effects of the use of lime with mineral sources of Nitrogen.
4. Comparison of Nitrate of Soda and Potash with Nitrate of Potash.
5. Comparison of different organic sources of Nitrogen.
6. Testing the effect of treating hair and leather waste with acid upon the availability of their nitrogen.

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*Lime applied at the rate of twenty bushels (1600 pounds) per acre.

TREATMENT GIVEN PLOTS.

All the fertilizers were applied broadcast, after the ground had been plowed and harrowed once, and then it was harrowed in immediately so as to get it thoroughly and uniformly incorporated with the soil, before planting the crop. There was no fertilizer applied directly to the hay crops. The effects on this crop were those of the residue from the wheat crop. Crimson clover was seeded in the corn crop of 1897 and this was plowed down in 1898 and the land followed for wheat. The general system of cultivation and cropping was uniform throughout.

The plots received an application of two-hundred (200) pounds per acre of undissolved Florida Phosphate rock at the time of seeding the wheat crop of 1902. There has been no potash applied up to this time.

RESULTS OF EXPERIMENTS.

The seasons, aside from that of 1897, covered by these experiments, were generally unfavorable to the crops grown. Hence, the results obtained are somewhat disappointing in that they have not given as marked returns as were expected. The yields from the Phosphoric Acid series of plots, and those of the first crops of this series, were such as to indicate that Nitrogenous Fertilizers would have more marked effects, and enable some more definite conclusions to be drawn.

It may be that the heavy applications of nitrogen caused an unbalancing of the plant food rations, and thus, gave results that might be, in many cases, misleading, but the character of the growth has not indicated that there was too much present. This point will be studied carefully in connection with the future conduct of these experiments. The results which are reported in the following give a summary of six years work and, ordinarily, would be expected to give facts which would be more or less conclusive, yet they are so erratic in some cases, that they would seem to need further verification before setting them down as representing all the facts. However, the results are reported here in full so as to make them a matter of record, and to serve anyone who may be interested in similar lines of work.

THE EFFECTS OF APPLYING NITRATE OF SODA AT DIFFERENT STAGES OF PLANT GROWTH.

There is a good deal of question in the minds of those using fertilizing materials which are very soluble, and which do not readily form insoluble combinations in the soils as to the best way and time to apply them. It is not unfrequent that advice is given to apply such materials at different periods in the plants' growth, rather than all at once, when there would be danger of loss, or at least leaching into the sub-soil beyond the reach of the crop.

There is no doubt but that the results attending the various practices will be largely determined by the character of the soil, the season and the crop. So that what would be a good practice in one case may not obtain or be applicable, to another or to all cases equally. The results of these tests are reported in detail in table V, page 42.

TABLE V.

Showing the Results of Applying Nitrate of Soda at Different Stages of the Plants Growth.

(Yields per acre.)

Plot No.	Kind of Fertilizer and Method of Application	Corn, 1897.				Corn, 1901.				Yield of 2 crops		
		Grain		Fodder lbs.	Total yield lbs.	Grain		Fodder lbs.	Total yield lbs.	Grain lbs.	Fodder lbs.	Total lbs.
		Bushels	Pounds			Bushels	Pounds					
	NITRATE OF SODA											
1	Applied just before planting	73.1	5120	3080	8200	49.8	3490	3020	6510	8610	6100	14710
2	Supplemented with lime applied before planting	72.8	5100	3020	8120	45.0	3130	2250	5380	8230	5270	13500
3	Applied at period of most active growth	62.8	4395	2780	7175	49.0	3420	2600	6020	7815	5380	13195
4	½ before planting ½ at time of most active growth.	71.7	5020	3060	8080	61.7	4220	2920	7140	9240	5980	15220
		Wheat, 1899.				Wheat, 1902.						
1	Applied just before planting	24.2	1452	3800	5252	5.7	340	260	600	1792	4060	5822
2	Supplemented with lime applied before planting	17.3	1038	2100	3138	5.2	310	190	500	1348	2290	3638
3	Applied at period of most active growth	14.3	858	1645	2503	6.5	390	310	700	1248	1955	3208
4	½ before planting ½ at time of most active growth	23.0	1380	3170	4550	11.2	670	680	1350	2050	3850	5900
		Hay. 1900		Hay, 1903		Total 2 crops hay.				Total yield six crops		
1	Applied just before planting	4300		4000		8300				28862		
2	Supplemented with lime applied before planting	5100		2830		7930				25068		
3	Applied at period of most active growth	3700		1800		5500				21898		
4	½ before planting ½ at time of most active growth	4450		2550		7000				28120		

As previously mentioned the soil on which these tests were conducted was a clay loam, rather stiff in character, under-laid with a very stiff clay; so that it was rather retentive of water and not much subject to leaching or loss of plant food. This may account for less marked results from applications received after the crop started to grow, than would be obtained on lighter or more pervious soils. Never-the-less, most of the soils, which are used for the staple crops, such as were grown in these tests, are nearly of the same general character as the soils of these plots. Consequently, these results may be held as representing the average conditions with the crops referred to.

The results favor the use of part of the Nitrate applied before planting the crop and part at the period of most active growth. It was most marked with the corn crop. This would naturally be expected as corn is a vigorous grower, and quite susceptible to special influences. It is doubtful if the increase would always justify the additional expense involved in making two applications, though no doubt, some seasons it would give ample returns.

These results certainly favor the use of Nitrate before planting, rather than after the crop is partially grown. It would seem that it is very important to give plenty of available food in the early stages of growth, so as to produce a good vigorous plant at the start, and then it will be in better shape to take care of itself in later life. The results of the hay crops do not figure largely in the question under discussion as the effects obtained were of an indirect character; as no fertilizer was applied to these crops after the wheat was removed, and it was only the residue remaining and the effects on the vigor of the young grass plants which would influence the yields. Never-the-less, it was thought of interest to include these results in this connection.

EFFECTS OF SPRING APPLICATIONS OF NITRATE OF SODA ON WHEAT.

In 1894 there were some tests made of top-dressing wheat in the spring, with Nitrate of Soda, and as the results are of interest in this connection, they are repeated here.

"With the object of testing the use of Nitrate of Soda applied in the spring as a top-dressing for wheat; two applications of it were made. The first was on a section of a half acre, which had received stable manure in its previous treatment, and had also been given a heavy dressing of a complete fertilizer when the wheat was sown and a light top-dressing of stable manure in mid-winter, besides fifteen bushels of stone lime per acre. The piece of land was divided into two equal plots, and on one of them Nitrate of Soda, at the rate of 150 pounds per acre, was sown the 14th of April, the other plot receiving none. As may be seen from the following table, the plot which received the Nitrate made less wheat by two bushels and thirty-eight pounds than that which received none. This result was unexpected and it is difficult to account for it, as the wheat was apparently heavier on the plot which received the Nitrate.

TABLE 6.

Nitrate of Soda vs. no Soda apdlied on Wheat.

Wheat heavily fertilized in the Fall.

Plot No.	Yield of grain, per acre. bushels.
1. **Fertilizer, no Soda**	25.9
2. **Fertilizer, with Soda**	23.2

The second test with Nitrate of Soda was made on a plot which had received no manure in its previous treatment nor was any fertilizer applied when the wheat was sown, but as in the first test, the wheat was treated to a light top-dressing of manure and stone lime in mid-winter. In this test as will be seen from table No. 7, the result was very striking, the grain being 7.8 bushels per acre, equal to 75 per cent. This experiment substantiates the theory held as to the use of Nitrate of Soda as a top-dressing for wheat, i. e., that it pays well as a rule on wheat, which, for any cause (either poor land or from late seeding,) is backward in the spring, giving it an impetus which no other application would secure, but that its use is of doubtful benefit on land which is well supplied with plant food.

TABLE 7.

Nitrate of Soda vs. no Soda apnlied on Wheat;

Wheat unfertilized in Fall.

Plot No.	Yield of grain per acre. Bushels.
1. Neither fertilizer nor soda	10.4
2. Soda, with no fertilizer	18.1

COMPARISON OF NITRATE OF SODA AND SULPHATE OF AMMONIA BOTH WITH AND WITHOUT LIME.

As has already been explained, the Nitrate of Soda and Sulphate of Ammonia represent the mineral sources of nitrogen commonly found on the market. The Nitrate of Soda is readily soluble in water and is directly available to plants; while the Sulphate of Ammonia, though quite soluble, has to be changed into a Nitrate before it can be used by crops. Hence the action of these two materials is not the same on different soils and under varying weather conditions. The Sulphate has been preferred by some because it would act slower and was not so liable to leach from the soil; yet if conditions for nitrification were unfavorable, it might not be available to the crop when needed. Again, under some circumstances Sulphate of Ammonia has been found to be actually harmful to plants. The use of Lime in connection with the Sulphate of Ammonia has been found by H. J. Wheeler* to be valuable, in many cases, as a correction of its harmful effects and to be necessary for its nitrification. Prof. Wheeler* has made a very exhaustive study of the use of Lime with these mineral sources of nitrogen, and while there were some variations in the behavior of different crops, yet they agree, in the main, with the results obtained at this Station.

TABLE VIII.

Comparison of Nitrate of Soda and Sulphate of Ammonia Both With and Without Lime.

(Yields per acre.)

Plot No.		Corn, 1897.				Corn, 1901				Yield of 2 crops corn		
		Grain				Grain						
		Bushels	Pounds	Fodder lbs.	Total yield lbs	Bushels	Pounds	Fodder lbs.	Total yield lbs.	Grain lbs.	Fodder lbs.	Total lbs.
	Without Lime											
1	Nitrate of Soda............	73.1	5120	3080	8200	49.8	3490	3020	6506	8606	6100	14710
8	Sulphate of Ammonia ..	65.8	4610	2700	7310	39.6	2772	2550	5322	7382	5250	12632
	With 20 bushels lime per acre											
2	Nitrate of Soda............	72.8	5100	3020	8120	45.0	3130	2250	5400	8250	5270	13500
9	Sulphate of Ammonia....	59.6	4170	2680	6850	44.7	3130	2600	5730	7300	5280	12580
	Without Lime	Wheat, 1899.				Wheat, 1902.						
1	Nitrate of Soda......... ...	24.2	1452	3800	5252	5.7	340	260	600	1792	4060	5852
8	Sulphate of Ammonia. ..	12.3	738	1610	2348	16.3	980	1070	2050	1718	2680	4398
	With 20 bushels lime per acre											
2	Nitrate of Soda.............	17.3	1038	2110	3148	5.2	310	190	500	1348	2300	3648
9	Sulphate of Ammonia....	9.9	115	1605	1720	11.3	680	870	1550	795	2475	3270
	Without Lime	Hay 1900		Hav 1903		Total 2 crops Hay				Total yield six crops.		
1	Nitrate of Soda....	4300		4000		8300				28862		
8	Sulphate of Ammonia....	1900		1900		3800				20830		
	With 20 bushels lime per acre											
2	Nitrate of Soda.........	5100		2830		7930				25068		
9	Sulphate of Ammonia....	4150		2250		6400				22850		

The details of the results of these two mineral nitrogenous plant foods, both with and without lime, is given in table 8, page 45. From numerous results, both in this country and in Europe, it would seem that Nitrate of Soda was much better as a source of Nitrogen than Sulphate of Ammonia, and the latter should only be used on soils, either already rich in Lime, or to which Lime had been applied, and even then it is necessary to have the conditions favorable for nitrification. The nitrogen in the Ammonia Salt generally costs more than that in Nitrate of Soda. Consequently, all things concerned, it has no advantages for most crops.

(*Annual report, Rhode Island Agricultural Experiment Station for 1895.)

COMPARISON OF NITRATE OF POTASH AND NITRATE OF SODA, SUPPLEMENTED WITH POTASH.

A number of times, during the past few years, there have been reports of discoveries of large deposits of Nitrate of Potash, and statements to the effect that this would become not only an important, but cheap source of both nitrogen and potash. However, up to the present time, these reports have not been realized, and unless this material possesses some special virtue which can not be procured through some other means, it is a relatively expensive source of nitrogen and potash. There has been a tendency, during the past years, to try and purchase concentrated plant foods, and get as little of those things which are useless as possible, and from this standpoint, the Nitrate of Potash is particularly attractive.

TABLE IX

Comparison of Nitrate of Potash with Nitrate of Soda and Sulphate of Potash.

(Yields per acre)

Plot No.		Corn, 1897.				Corn, 1901				Yield of two corn crops.		
		Grain				Grain						
		Bushels	Pounds	Fodder lbs.	Total yield lbs	Bushels	Pounds	Fodder lbs.	Total yield lbs.	Grain lbs.	Fodder lbs.	Total lbs
6	Nitrate of Soda and Sulphate of Potash..	76.2	5340	3140	8480	50.0	3500	3100	6600	8840	6240	15080
7	Nitrate of Potash	77.4	5420	3350	8770	55.1	3855	3450	7305	9275	6800	16075
		Wheat, 1899.				Wheat, 1902						
6	Nitrate of Soda and Sulphate of Potash ..	19.5	1170	2380	3550	14.5	870	930	1800	2040	3310	5350
7	Nitrate of Potash..	17.0	1020	2530	3550	16.2	970	1180	2150	1990	3710	5700
		Hay 1900		Hay 1903		Total of 6 crops.				Total of six crops.		
6	Nitrate of Soda and Sulphate of Potash.........	4050		2200		7250				27680		
7	Nitrate of Potash............	4400		2950		7350				29125		

In the experiments conducted here, Nitrate of Soda and Sulphate of Potash were combined so as to furnish the same amount of nitrogen and potash as supplied by the Nitrate of Potash. The details of the results are given in Table 9, Page, 46 from which it will be seen that they favor the Nitrate of Potash, but not to a great enough extent to warrant the difference in cost which usually prevails.

COMPARISON OF VARIOUS SOURCES OF ORGANIC NITROGEN.

The sources of organic nitrogen are rather difficult to compare, as a class, from the fact that they contain varying amounts of other plant foods which must influence the results to a greater or less extent. The various materials used in these experiments, are described in detail in the first part of this bulletin together with the chemistry of the action of organic materials and the process of nitrification. The results are given in detail in Table 10, Page, 48 In general the results would seem to indicate that the organic sources of nitrogen were not so active as Nitrate of Soda; though there might be a slight difference in the natural fertility of the land, in favor of the Nitrate of Soda.

ORGANIC FERTILIZERS CONTAINING ONLY NITROGEN.

Dried Blood, Leather and Hair.

An examination of the yields of Plots No's. 12 to 18, seems to indicate that Dried Blood is not as potent a source of Nitrogen as it is commonly supposed. In these tests the blood seemed to exert a favorable influence on the grain yields, but did not seem to have the lasting qualities for the hay crops to follow. The yields would seem to indicate that of these three, as a source of nitrogen, the blood would stand first, leather second, and hair last.

TABLE X.

Comparison of Various Sources of Organic Nitrogen.

(Yields per acre.)

Plot No.		Corn, 1897.				Corn, 1901				Yield of two corn crops.		
		Grain				Grain						
		Bushels	Pounds	Fodder lbs	Total yield lbs.	Bushels	Pounds	Fodder lbs.	Total yield lbs.	Grain lbs.	Fodder lbs	Total lbs.
	Nothing (ave plots 10, 11.)	55.3	3870	2610	6480	39.3	2750	2635	5385	6620	5245	11865
12	Dried Blood	60.1	4210	2690	6900	42.7	2990	2650	5640	7200	5340	12540
13	Raw leather waste	55.7	3900	2580	6480	36.4	2550	2720	5270	6450	5300	11750
14	Dissolved leather waste	60.0	4200	2640	6840	46.0	3220	2650	5870	7420	5290	12710
	Nothing (ave plots 15, 16.)	61.3	4290	2585	6875	37.3	2610	2705	5315	6900	5290	12190
17	Raw hair waste	61.4	4295	2780	7075	37.1	2600	2650	5250	6895	5430	12325
18	Dissolved hair waste	58.4	4090	2670	6760	36.5	2555	2950	5505	6645	5670	12265
19	Bone tankage	56 8	3980	2660	6640	40.0	2800	2700	5500	6780	5360	12140
20	Dried fish	69.1	4840	3360	8200	47.4	3320	3370	6690	8160	6730	14890
22	Cotton seed meal	56.2	3930	2880	6810	37.1	2600	2650	5250	6530	5530	12060
23	Stable manure	51.4	3600	2480	6080	40.1	2810	2750	5560	6410	5230	11640
	Nothing (average plots 21, 24, 26, 28.)	51.9	3635	2785	6420	39.6	2772	3142	5914	6407	5927	12334
	Lime (ave plots 25, 27.)	49.0	3430	2645	6075	36.0	2520	2900	5420	5950	5545	11495
		Wheat, 1899.				Wheat, 1902.				Total 2 wheat crops.		
	Nothing (ave plots 10, 11.)	9.4	565	1283	1848	8.6	515	485	1000	1080	1768	2848
12	Dried blood	10.8	650	1155	1805	9.2	550	550	1100	1200	1705	2905
13	Raw leather waste	8.9	535	1865	2400	6.0	360	190	550	895	2055	2950
14	Dissolved leather waste	10.8	650	1900	2550	7.8	470	630	1100	1120	2530	3650
	Nothing (ave plots 15, 16.)	6.0	360	1415	1775	4.4	264	210	474	624	1625	2249
17	Raw hair waste	7.4	445	1655	2100	2.0	120	80	200	565	1735	2300
18	Dissolved hair waste	7.5	450	1550	2000	5.0	300	250	550	750	2300	3050
19	Bone tankage	18.2	1090	2610	3700	7.2	430	220	650	1520	2830	4350
20	Dried fish	24.3	1460	3640	4100	12.0	720	830	1550	2180	3470	5650
22	Cotton seed meal	14.2	850	1900	2750	6.8	410	390	800	1260	2290	3550
23	Stable manure	17.5	1050	2700	3750	4.3	260	140	400	1310	2840	4150
	Nothing (average plots 21, 24, 26, 28.)	13.6	815	1848	2663	8.3	498	338	836	1313	2186	3499
	Lime (ave plots 25, 27.)	13.4	805	2148	2953	3.5	210	115	325	1015	2263	3278
		Hay--pounds per acre								Total yield 6 crops.		
			1900		1903			2 crops				
	Nothing (ave plots 10, 11.		2475		1300			3775			18488	
12	Dried blood		3400		1700			5100			20545	
13	Raw leather waste		4400		1750			6150			20850	
14	Dissolved leather waste		3700		2200			5900			22160	
	Nothing (ave plots 15, 16.)		3075		1940			5015			19454	
17	Raw hair waste		3500		2100			5600			20225	
18	Dissolved hair waste.		3200		1550			4750			20065	
19	Bone tankage		4050		2550			6600			32090	
20	Dried fish		4500		3100			7600			28140	
22	Cotton seed meal		2950		1900			4850			20460	
23	Stable manure		3950		1500			5450			21240	
	Nothing (average plots 21. 24. 26, 28)		2600		1725			4325			20158	
	Lime (average plots 25 27)		2625		2075			4700			19473	

RAW VS. DISSOLVED LEATHER AND HAIR WASTE.

It has become a common practice during the past few years to mix such materials as hair, leather, waste, etc., with rock before treating it with acid, and thus get the benefit of the action of the acid on this matter, at the same time the rock is being dissolved. It is claimed that this treatment puts the nitrogen of these materials in a condition to be readily available to plants and removes all objection to the use of such material as a sonrce of Nitrogen. In order to test this claim, both the raw and acid treated leather and hair were used in these epxeriments. They were treated with acid here at the Station, so that there would be no doubt about each plot receiving the same amount and kind of waste. The results are given in Table 10, Page 48. Plots No. 13 to 18, and seem to show some decided advantage resulting from treating the leather with acid, but none from treating the hair, except with the one crop of wheat.

ORGANIC NITROGENOUS FERTILIZERS CONTAINING PHOSPHORIC ACID.

Bone Tankage and Dried Fish.

These fertilizers were applied so as to furnish the same quantity of Nitrogen, and there was very nearly the same quantity of Phosphoric acid, though slightly more in the fish than the tankage. For details of yields see plots 19 and 20 Table 10, Page 48. It will be seen that the fish gave much better yields, in every case, than the tankage, and would seem to leave but little doubt as to which to prefer at the same price. The different actions of these two materials is hard to explain, but it is probably due to the greater facility with which nitrification can take place in the fish. The results of these two fertilizers seem to indicate the value of the Phosphoric Acid on the land used.

NITROGENOUS FERTILIZERS CONTAINING BOTH PHOSPHORIC ACID AND POTASH.

Cotton Seed Meal and Stable Manure.

These manures were applied so as to furnish the same quantity of Nitrogen as was received by the other plots. This made what would be considered a rather light dressing of manure, being only about 3 1-5 tons per acre; yet this represented considerably more organic matter than was received by other plots, and it was expected that this would be quite beneficial as the land was thought to be deficient in this respect. The yields from the stable manure were better than from Cottonseed Meal, but were not as large as were expected, and did not show the manure to be a very superior source of nitrogen.

MISCELLANEOUS EXPERIMENTS WITH NITROGENOUS FERTILIZERS.

From time to time, there have been conducted by this Station, numerous experiments with nitrogenous fertilizers, most of which have never been reported, but as this is a subject of general interest it was thought best to bring them all together in this one publication.

TOP-DRESSING GRASS LAND.

The piece of land used in this test had been cut for hay the two previous years. It was a good orchard grass sod, and contained some clover.

The fertilizer was applied broad-cast, by means of a grain drill with the hoes up, April 2nd. 1903. The fertilizer seemed to produce a marked effect at once, and gave indications of a large yield, but the latter part of April, the weather turned suddenly dry, and abnormally cool and remained so until the orchard grass was in bloom and it was time for cutting the crop for hay, so that the yield was not more than one-half of what was expected. A Farmers' Club, that visited the Station near the middle of April, thought that the crop gave indications of a yield of three tons per acre. The dry cool weather was favorable for the action of the fertilizers yet the increased yield, rated at 60 per cent, gave a net profit from the Nitrate of Soda of about $2.75 per acre, and left the land in better condition as the second growth on this plot was better. The dried fish, not being so active, did not give as large an increase, and as it cost more, there was no profit from its use.

The following table gives the details of treatment and results:

Plot No.	Kind and quantity of fertilizer.	Yield of hay per acre.
1.	Dried Fish, 200 lbs. per acre........................	2450 lbs.
2.	(Nitrate of Soda, 100 lbs. per acre. Dissolved S. C. Rock, 100 lbs per acre....................................	2865 "
3.	No fertilizer....................................	2040 "

The fertilized plots received, approximately, the same quantity of plant food.

TOP-DRESSING LAWN.

There is considerable interest in the matter of fertilization of lawns, and frequent inquiries come to the Station for information on the subject. The chief reliance is in the use of stable manure applied during the fall or winter, and while this gives fairly good results, yet it is not satisfactory from the fact that it is not only difficult at times to procure it, but when applied it is always unsightly and sometimes gives rise to disagreeable odors. The coarse parts always have to be removed in the spring, and generally leaves the lawn spotted and uneven in appearance. Then, too, there is always more or less danger of introducing objectionable weeds with the manure.

The stable manure, which is applied in the fall or winter, is always raked off early in the spring which gives the land only the benefit of the soluble portions which evidently remains in the lands during the winter without much loss from leaching. Having observed that spring applications of commercial fertilizers had a tendency to cause the grass to suffer from drought, it was decided to try fall or winter applications of Commercial Fertilizers. The experiment Station Lawn was used for this test. It consisted of a good Kentucky blue grass, and white clover sod seeded down the fall of 1898.; The land is a stiff clay loam. The details of this test were conducted by Thos. H. White, Gardiner. The following is the plan of the experiment.

TABLE 12.

Plots 10 *feet wide and* 83 *feet long.*

Plot No.

1. Fresh horse stable manure, at the rate of 15 tons per acre.
2. Tankage, 1700 lbs. per acre.
3. Nitrate of soda, 900 lbs. per acre.
4. Raw Phosphate Rock, 300 lbs., Muriate of Potash, 288 lbs., Tankage, 850 lbs. Nitrate of Soda, 450 lbs., per acre.
5. Nothing.
6. Same as No. 4, with 2000 lbs. of Lime per acre, applied a few days before the fertilizer.
7. Wood ashes, 2900 lbs. per acre.
8. Muriate of Potash, 288 lbs. per acre.
9. Muriate of Potash, 288 lbs. and Lime 2000 lbs. per acre.
10. Lime 2000 lbs. per acre.
11. Slag Phosphate, 350 lbs. per acre.
12. Dissolved South Carolina Rock, 450 lbs., per acre.

The manure and fertilizer was applied January 9th, 1902. The fifteen tons per acre of stable manure used, completely covered the grass. The tankage being dry and rather bulky, gave the plot to which it was applied a dark brown appearance, which, however, was washed by the first rain and the grass assumed a dark green color which it maintained all winter, and which was much more pleasing than the straw of the manure along-side.

The Nitrate of Soda turned the grass a brown similar to the action of frost which did not disappear until spring. The plots receiving potash had about the same appearance as the Nitrate of Soda Plots, but they did not become green as early in the spring.

In tests of this sort, no record of yields could be made, so that the only results available are those which could be obtained by observation and taking notes.

Notes taken March 13, 1902.

Plots No. 1. Removed the litter of the stable manure. The grass had made some growth, was spotted and somewhat bleached in appearance.
Plot No. 2. Grass a very dark green color which it had acquired a few days after the application of the tankage was made.
Plot No. 3. Beginning to turn green and outgrow the injury caused to the foliage by the heavy application of the Nitrate.
Plot No. 4. Quite green, better than No. 1 or 3, but not so good as 2.
Plot No. 5. Shows very little signs of growth.
Plot No. 6. Probably a little better than No. 4. There is nothing noticeable in the remainder of the plots, and they look just about like No. 5.

Notes taken April 14, 1903.

The relative condition noted one month ago, obtains today. The growth of the plots receiving fertilizer is quite rank, and it is necessary to cut these.

The difference can be better appreciated by the fact that Plot No. 2, (Tankage) was uniformly three inches higher than lot No. 5, (Nothing). The heighth and appearance of the grass on the plots, ranked as follows: Plot 2, 6, 4, 3, and 1. Plots 5, 7, 8, 9, 10, 11, and 12, showed no appreciable difference.

Season 1902-1903.

The top-dressing of the lawn plots was repeated. The applications being the same as the previous year, with the exception that Fish Tankage was used instead of Bone Tankage.

The results of this year's work support that of last year in every particular.

There seems to be no noticeable difference as to the drought resisting powers of the various plots. All things considered, it would seem that either bone or fish tankage is the most desirable material for top-dressing lawns and for the city or town lawn is much easier to get, cheaper, and more agreeable to use than stable manure.

THE USE OF NITROGENOUS FERTILIZERS ON VEGETABLES.

Kale.

An application of 50 lbs. of Nitrate of Soda and 100 pounds of Dried Fish per acre, in May, increased the growth 30 per cent.

Lettuce.

An application in March at the rate of 250 pounds of Nitrate of Soda and 750 pounds of Dried Fish per acre, to Lettuce, in cold frames, made the crop ready to market one week sooner and increased the yield five pounds per sash or 12000 pounds per acre; which at two cents per head would have a value of $240.00 per acre.

Potatoes.

Several experiments have been tried on the use of Nitrate of Soda as a top-dressing for early potatoes. This was applied at the rate of 100 pounds per acre, after the potatoes were up and started to growing. One year this treatment increased the yield of merchantable potatoes 100 bushels per acre, and the average of several years was 20 per cent increase.

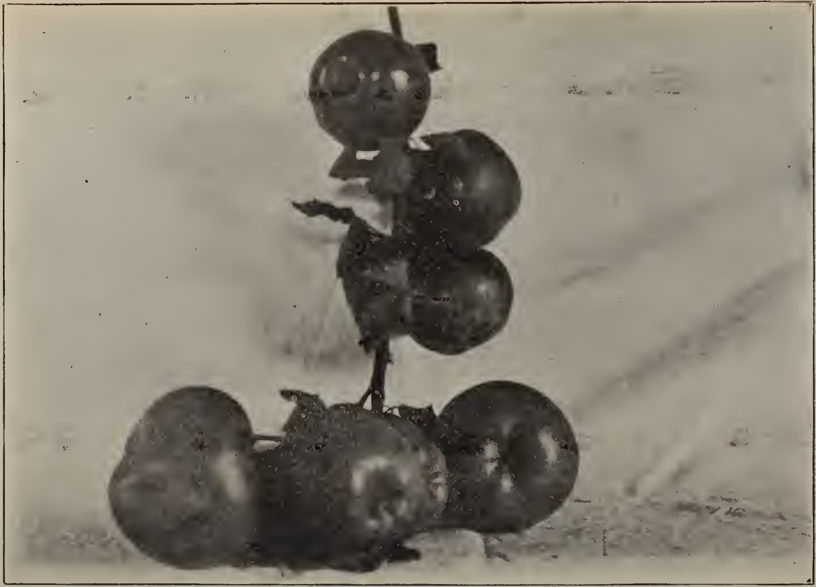
Tomatoes.

Some of the early work of this Station was with fertilizers for tomatoes. The results in detail are given in Bulletin No. 1, but it showed that Nitrate of Soda was particularly active with this crop and produced a larger increase than any other single ingredient. An application of 160 pounds per acre caused an increase of as much as five tons of tomatoes.

There has been much valuable work conducted upon the use of Nitrogenous Fertilizers with various crops, and particularly vegetables. This work has proven that this plant food is a potent factor in increasing the yields and improving the quality.

Among the many bulletins pertaining to the fertilization of vegetables subject the following are worthy of special mention, and would be of particular interest to truck growers:

"The Manuring of Market Garden Crops," by Bernard Dyer, Rothamsted Experiment Station. Bulletin No. 69 Rhode Island Experiment Station. Bulletin No. 141, New Jersey Experiment Station; Bulletin No. 66 Massachussetts Experiment Station; and Bulletin No. 84 Indiana Experiment Station.



Branch of Kinnaird (Original).

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 92. **March, 1904.**

NOTES ON APPLE CULTURE.

By C. F. Austin.

INTRODUCTION.

While apples have been grown in Maryland from the earliest time, they have never received the attention that they should from the leading fruit men.

The business of commercial apple growing has never received the attention that is necessary to bring it up to a standard that will win a place in the markets for the apples of this State. Maryland has never been rated as one of the apple producing states, although she has the soil and climatic conditions favorable to producing fruit of high Commercial value. The only thing that seems lacking is for men to take hold of apple growing in a thorough, up-to-date business manner, and put into actual practice the horticultural operations that are necessary to succeed in any line of fruit growing.

Maryland lies in the same range of latitude as many of the states that have won fame from the product of their apple orchards. Western Maryland is especially adapted to the growing of late fall and winter apples of fine quality, color, and appearance. There are many idle hillsides that could be made a profitable investment by putting them into apple trees. While a small State in the number of square miles, it has wonderfully varied soil and climatic conditions, reaching as it does from the tide waters of the Atlantic on the east to the rugged ranges of the Alleghanies on the west. It is possible under such varied conditions to grow apples adapted to all seasons of the year.

While the Southern and Eastern sections of the State are not adapted, except in the more favored localtites, to producing late fall and winter apples, they have the advantage of producing an especially fine summer and early fall product. The rolling lands of northern and western sections of the State produce a late fall and winter apple that compares favorably, and in many instances is better than, the product of our more renowned apple districts.

The State also has the advantage of fine railroad transportation to all the large cities of the East and water transportation to markets of England and Europe.

It seems to be the current notion in this State, that the apple is a fruit that thrives under neglect and want of care, the only thing being necessary is to set the trees in some out-of-the way place, usually the

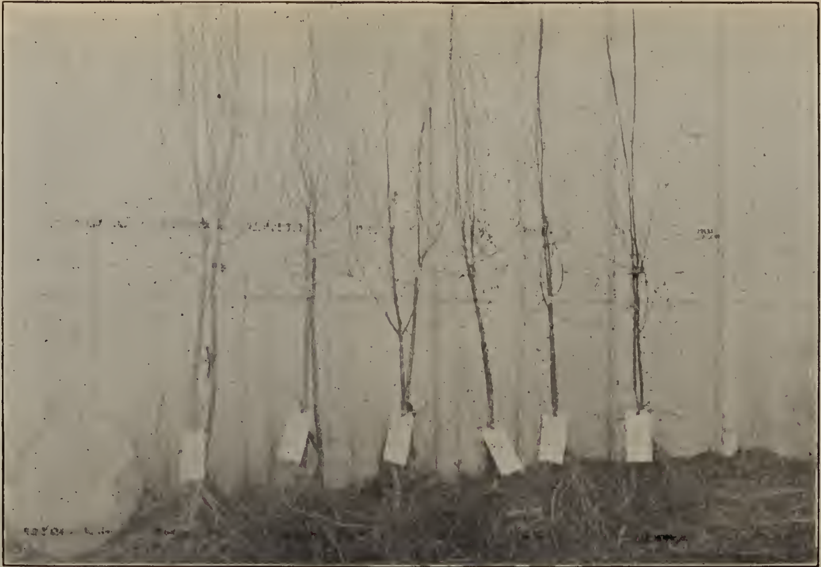


FIGURE 1. Grades of trees as sold (original) No. 1 ¾ of one inch and up in diameter. No. 2 ⅝ of one inch to ¾ of one inch in diameter. No. 3 9-16 of one inch to ⅝ of one inch in diameter. No 4 ½ of one inch to 9-16 of one inch in diameter. No. 5 3 feet to fou feet high. No. 6 2 feet to 5 feet high.

poorest part of the farm. The orchard is given little or no cultivation, except what is necessary to produce some other crop among the trees, while pruning, spraying, thinning, and many of the other operations looked upon by the successful orchardist as necessary to success, are not taken into consideration. Among surroundings of this character, we expect to harvest the beautiful red-cheeked apple with which to add to our finances, as well as to the enjoyment of our friends on a long winter evening. It is also from such surroundings that comes the complaint that "apple raisin" don't pay." May I ask, should it pay?

The time is past when successful orcharding can be done under such conditions and surroundings. The time is at hand when profitable apple growing must be put upon a business basis, and attended to with the proper horticultural practices.

It is the purpose in the following pages to call attention in a brief way to some of the principles and methods that are considered by successful orchardists as absolutely essential to successful apple growing.

LOCATION.

The question of location is a very important one, and should receive very careful consideration from the prospective apple planter. The two points that should be considered are first, soil drainage, and second, atmospheric drainage. Apple trees will not be a success upon low, wet land. The best location is one where there is abundance of natural drainage. High, dry, rolling lands will give good results. Where there is not sufficient natural drainage, much can be done by artificial drainage. The low, wet pockets that are found should always be drained. Low, wet, flat bottom lands should be avoided. There is very little danger from want of atmospheric drainage upon rolling lands, for the cold air settles into the valleys and is drawn off to the flat lands where it remains stationary upon still nights. This is the reason that low, flat lands suffer from early fall and late spring frosts, for the cold air settles upon them, while the higher lands surrounding escape these dangers.

THE SOIL AND ITS PREPARATION.

The apple tree is quite cosmopolitan in regard to the soil best adapted to it. Much more depends upon the location with reference to soil and air drainage, selection of varieties, and proper cultural methods than upon any peculiar class of soil, as clay, loam, etc. A fertile gravelly loam, well filled with vegetable matter is to be preferred to a stiff clay on account of the ease with which the soil is drained. Where a lime stone soil is to be had, it is to be preferred to all others. A rocky soil will many times give wonderful success with apples.

Too much attention cannot be given to the preparation of the soil before the trees are planted. It should be plowed deep and thorough and well harrowed to give a good, smooth, mellow surface.

TERRACING.

After looking over many parts of the State, we are convinced that the fruit growers will find some form of terracing very profitable. By the use of the terrace many of the hilly places could be very easily cultivated,

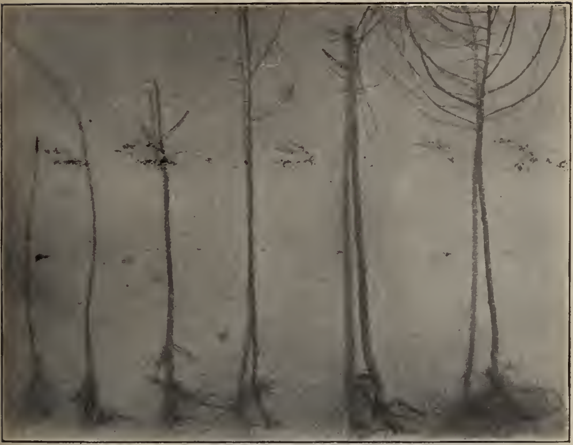


FIGURE 2. Showing a large, medium, and small tree pruned and unpruned at setting time. (original)

and the washing that is so common during the hard fall and spring rains would be to a large extent prevented. The system is a very simple one. The terraces are laid off according to the contour of the hills. A terrace level is used where the hill sides are steep, but when not very steep good work can be done with an ordinary level and the eye. For orchard work it is best to lay out a terrace for each row, as, for instance, if the rows are forty feet apart, the terraces would be forty feet wide. The trees to be planted upon the top of each terrace and the rows run around the contour of the hillside, and not set in squares or checks as is the usual plan.

The cultivation of the orchard is around the terraces in one way. The bank of the terrace should be seeded to some form of binder grass, as Kentucky Blue.

The principal value of the terrace is the preventing to a large extent of the washing and gullying so common in many sections, and also making it possible to plant many hill sides that would be too steep for planting by the ordinary methods.

TIME TO PLANT TREES.

The question of fall or spring planting has always been debated among fruit growers, and probably always will be. There are many things in favor of both sides. But in all sections where there is a comparatively mild climate as it is in Maryland, fall planting will give the best results. Any warm days during the fall and early winter may be used for this work.

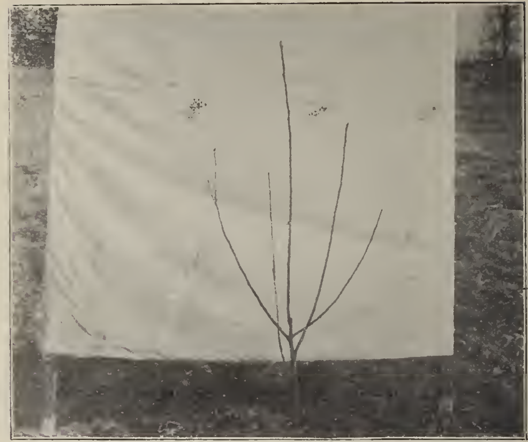


FIGURE 3. Showing a one year tree unpruned. (original)

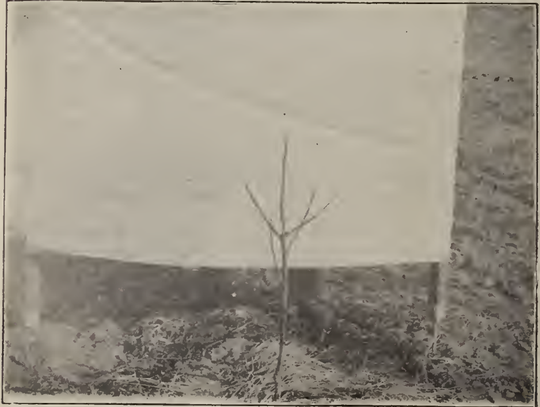


FIGURE 4. Showing a one year tree pruned. (original)

Among the things in favor of fall planting the following may be named. It is a time of the year when labor is plenty. There is an opportuniy to take more pains in planting the trees than during the rush of the spring work. The main reason for fall planting is, that the tree becomes firmly fixed in the soil and is ready to start growth with the opening of spring. If the winter is warm and mild there will sometimes be some growth of fibrous roots, which helps to further hold the tree in the soil and insure it a good early start. With spring planting there is no danger of the tree being winter killed, though this rarely occurs in a climate as mild as is found in this State.

DISTANCE TO SET TREES.

The distance will vary somewhat with the variety of the trees. There is always a tendency to set them too close rather than too far apart. A tree should have plenty of room to grow and develop. A provision should be made for the free circulation of air, and the admittance of abundance of light, around and through the trees, when they are full grown and full of fruit and leaves. Forty feet each way is none too far apart for the large spreading varieties. With many of the slower growing and more erect sorts, thirty to thirty-four feet will give good results. We must remember when planting an apple orchard that it is not for eight or ten years, but for twenty or fifty years, and in that time trees grow to a very large size and demand a large amount of room for their best development. A saving of a few feet of ground is often the cause of much inconvenience in working the orchard as it becomes older, and a loss of money by not being able to produce a fine grade of fruit on account of the trees being too crowded.

DOUBLE PLANTING.

It is often recommended to plant the trees that are to form the permanent orchard at the same distance apart, or even a few feet farther apart, and then fill in the space between the trees with some early maturing variety of apples, or with some other fruit trees, as peaches, plums, or pears. The object to be gained is that the early maturing trees planted in as fillers will come into bearing sooner than the permanent orchard trees, and help to pay the expenses of the plantation. The early varieties are to be cut out as soon as they begin to interfere with the permanent trees. Right here is where the trouble comes in for few people will cut out the fillers as soon as they ought to be taken out. If this is done all right and good.

But, as a rule, it would be far better, to rely upon some form of spring cropping of the permanent orchard to help pay the expenses while the trees are coming into bearing, than upon the method of double planting. The plan is theoretically an ideal one, in itself, there are serious objections to it in practice.

SETTING OF THE TREE.

Pains should be taken in setting a tree, for if it is worth setting at all, it is worth setting well. It is probably true that more trees die from improper and careless planting than from any other one cause. A large hole should be dug from sixteen to twenty four inches square, and deep enough

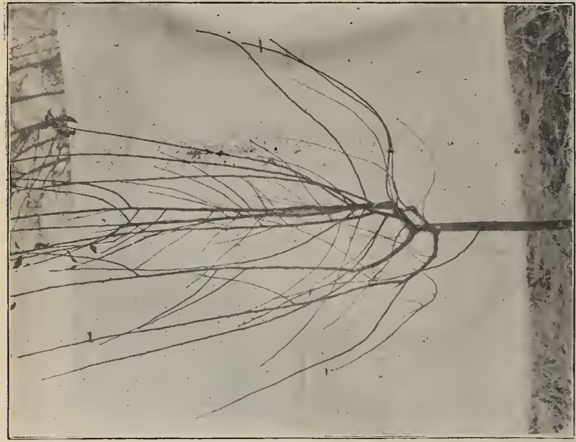


FIGURE 5. Showing a two year tree unpruned. (original)

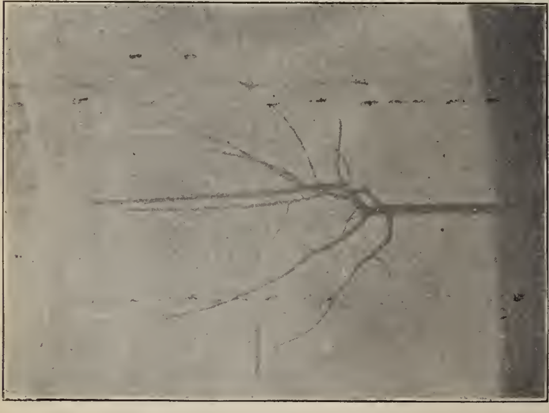


FIGURE 6. Showing a two year tree pruned. (original)

to allow three or four inches of the surface soil to be put in the bottom of it, and then have the tree so that it comes one or two inches deeper than it was in the nursery. After placing the tree in the hole, shovel in some loose mellow surface soil and carefully work it in around the roots, and when the roots are well covered, tramp the dirt firmly with the feet, and then fill up the balance of the hole with good soil and make it firm. Leave the surface of the soil loose and mellow so as to prevent evaporation. Be sure and fill the hole up well around the tree, so when the soil settles down there will not be a hollow where water can stand or run down around the trunk and roots of the tree.

AGE AND SIZE OF TREES TO SET.

A tree for planting should never be over two years old, and many prefer a good strong one year tree. The older the trees are, the harder they are to transplant and have them live well. The future growth of old trees from the nursery is very seldom satisfactory. It is not age that makes a first class tree.

Apple trees at present time are usually graded into six sizes by the leading nurserymen. The point that determines the size of the tree is the calier of the trunk just above the union of the scion and the stock. By the calier we mean the diameter of the trunk in inches or fractions of an inch. A first class apple tree of the first size is one that has a well formed root system, as smooth and straight a trunk as can be had of the variety wanted, for we must remember that all varieties are not the same as to the habit of growth; a well formed head or top having the branches well along the side, and a calier at the base of not less than three-fourths of an inch. A first class tree of the second size is one that has the same description as the former with a calier of five-eights of an inch to three-fourths of one inch. The third size is a tree same as the former, only somewhat smaller and caliering at the base nine-sixteenths of one inch to five-eights of one inch. The fourth size is a still smaller tree running from one-half inch at the base to nine-sixteenths of one inch. The fifth size, is smaller than one-half inch in diameter at the base and running three or four feet in height. The sixth size is a very small tree, running from two to three feet in height. See Fig. No. 1.

Many people who handle trees have a misleading way of grading trees according to the height in feet. As, for instance, a first-class tree is said to be one from five to seven feet. By this method it allows the putting in of trees of smaller diameter that have the required height. As, for example, a tree may not be over nine sixeenths of one inch in diameter and go in as a first class tree for it has a long slender weak trunk. By using the calier method in buying you can get the trees having the strong stiff trunk. Trees having crooked trunks, poorly formed heads or tops and deficient root system should not be had at any price, for a cheap tree is the most expensive of all. Good first class trees of the different grades from one half inch up will give good results.

HOME GROWN VS. NURSERY GROWN TREES.

Many people think they can grow their own trees and save the expense of buying them. It will usually be found to be cheaper to buy your trees of some good responsible nurseyman than to grow them yourself.

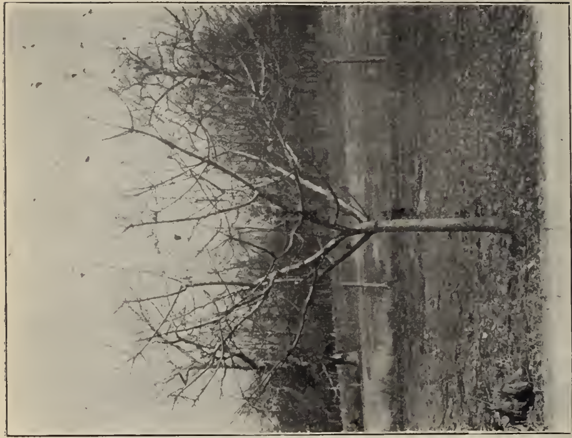


FIGURE 7. Showing a five year old tree unpruned. (original)

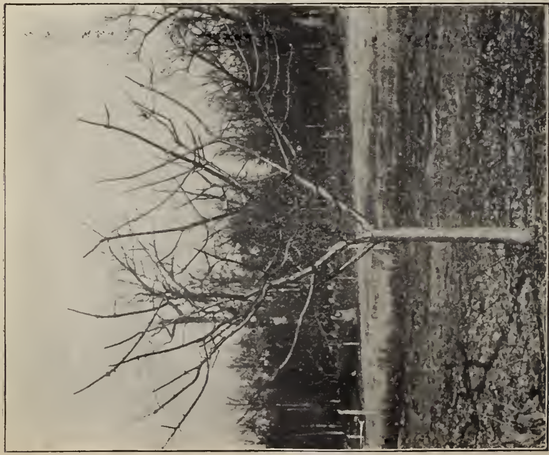


FIGURE 8. Showing a 5 year old tree pruned. (original)

Nursery stock demands special care and attention and the average farmer will not have the time to give it the attention it demands to make the undertaking successful. A poorly grown, stunted tree will be dear at any price. Do not grow your own trees unless you can grow them strong, vigorous, and thrifty.

PRUNING.

The question of pruning trees is very largely an individual matter, for there are no hard or fast rules to be laid down as to just how much shall or shall not be cut from the tree. Nearly every fruit grower has his own ideal of how a tree should look, so that one can only give some of the general principles of pruning and leave each one to work them into his method. In pruning a tree to set, one should remove all broken or mangled roots, using a smooth slanting cut. Fig. No 2. Any long sprawling roots can be shortened to fit a good sized hole. If the trees are very small and slender, the top should be pruned to a whip and then cut back to the required height. If a tree has a large top when setting it, most of this top should be removed. Three or four short branches may be left. We must remember that in setting a tree it is the roots that we want to take hold of the soil. The tree must be supported by the latent food stored up in the roots and branches until the roots can take hold of the soil to furnish food for its support The less top there is for the tree to support while the tree is young, the better chance it has to live. In forming the top or head of a tree, one should be particular to remove all cross limbs and crotches, for the cross limbs will soon begin to rub against each other, and the crotches will split as soon as there is a heavy load of fruit.

The pruning for the second year should be the formation of the top or head or in other words, the leaving of the number of branches that we want for permanent branches There should be from three to five limbs well distributed around the trunk so as to form a well balanced top See Fig. Nos. 3, 4, 5, and 6. The height from the ground that the head should be formed will depend very much upon the variety. The erect growing sorts can be started much closer to the ground than those that are spreading or drooping. Many of the erect growing varieties can be started as close as twelve to sixteen inches from the ground, while the more spreading ones from two to two and one half or three feet. The closer the head can be brought to the ground the better, for with our improved machinery for cultivation it is not necessary to have the trunks from four to five feet high. The pruning, spraying, and harvesting are operations that have to be done by hand and the closer to the ground we can get the heads of our fruit trees, the easier and cheaper can the most expensive part of the labor be done. The pruning for the third and fourth years and until the tree comes in to bearing should be along lines already indicated, thinning out the wood and cutting back the excessive growth to form as perfect a head as possible. See Fig. No. 7 and 8. In cutting back it is usually best to remove at least one half of the growth made the previous season. After a tree comes into full bearing it will not require as heavy pruning as while young and growing vigorously. The object in pruning the bearing tree should be to thin out sufficient wood to admit plenty of light and air to all parts of the tree. Sunlight

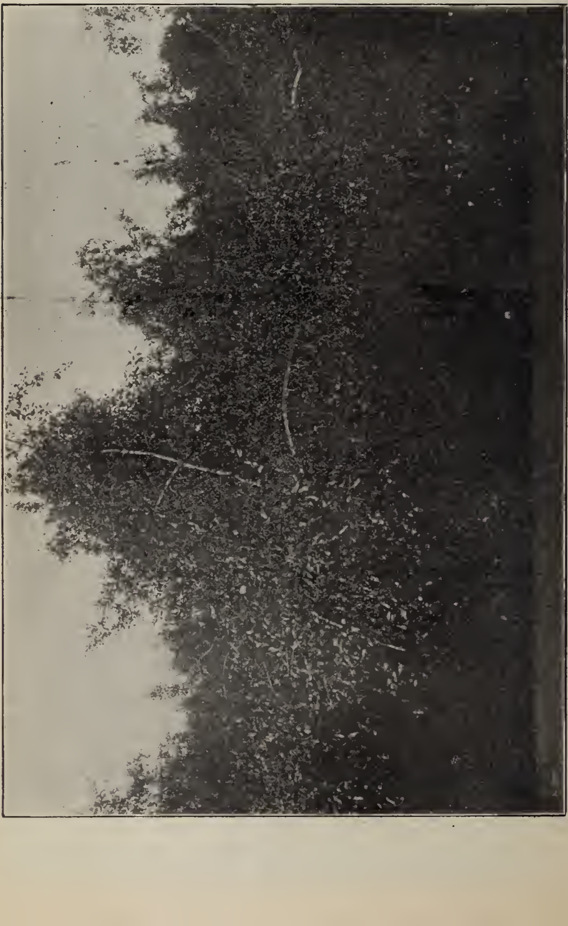


FIGURE 10, Showing trees broken and split to pieces by too heavy loads. Want of thinning. (original) is absolutely essential to grow apples of high color and flavor, and this cannot be done where there is a thick foliage. Many trees produce too much wood and this should be removed. All such growths as water sprouts along the main limbs should be removed. The pruning of a bearing orchard will seldom be excessive, but they should be gone over once a year to remove all dead or broken limbs, and whatever unnecessary wood growth there is. The trees of a bearing orchard will seldom need cutting back.

TIME TO PRUNE.

The best time is in the latter part of winter and early spring before the growth starts.

HOW TO PRUNE.

It is essential to make all the cuts smooth and as close to the main branches as possible, so as not to leave any stubs. When the cuts are made smooth, even and close to the limb, the wounds will heal over in a short time. But if a stub is left it can never heal over and it will cause a decayed spot or hole in the main limbs of the tree.

CULTIVATION AND CROPPING.

The question of orchard cultivation is a very important one and anyone looking forward to successful apple growing should give the matter careful attention.

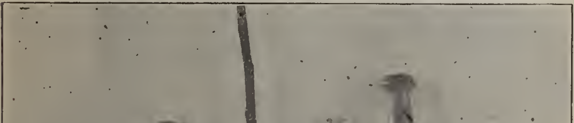


FIGURE 11. No. 1 showing a limb split with graft set in place. No. 2. Grafting mallet. No. 3. Two grafts showing thick and thin side of wedge shaped cut. No. 4. Grafting chisel. No. 5. A bundle of grafts. (original)

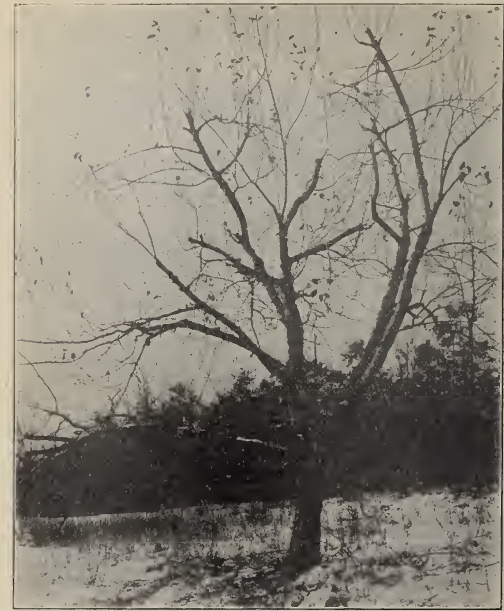


*FIGURE 12. Showing a grafted tree. The grafts were set in spring 1903 and photographed in December 1903. (original)

From the time an orchard is set out until it comes into fruiting, some early maturing crop can be grown among the trees. Such crops as early potatoes, tomatoes, early corn, cantaloupes, etc., are to be preferred for they mature early and the tree receives the cultivation during the growing period of the year. Fall crops that require late cultivation should be avoided for they cause the trees to grow so late in the fall that they do not have sufficient time to mature their wood for winter. Grains and grass crops should never be put in a growing orchard for they draw too heavily upon the soil and the moisture in maturing their seed. After the orchard comes into full bearing the trees will require all the soil and there should be nothing but a cover crop sown in the orchard.

In the spring after the grass starts, the orchard should be carefully

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*The photographs for figures 12, 13, 14, 15, were taken from the orchard of Mr. Charles F. Sweet, Swanton, Md.

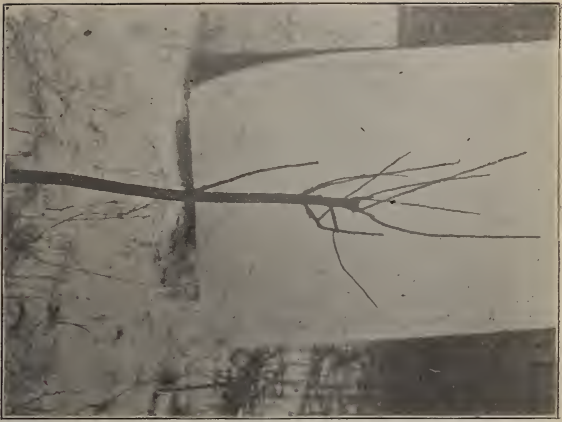

FIGURE 13. The lower limb is a side graft set in spring of 1903. This tree was top worked by whip grafting in spring of 1903. (original)

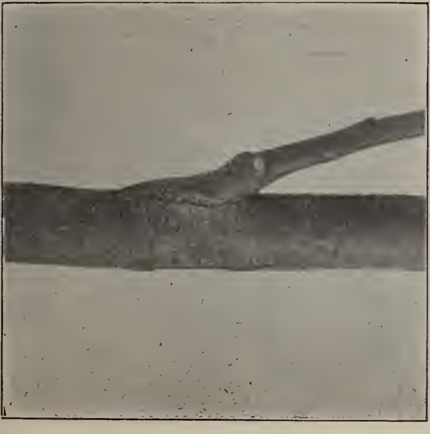

FIGURE 14. Shows the same graft as in figure 13 showing more completely the union and method of setting the graft. (original)

plowed from five to eight inches deep, over the whole space except close to the trees. The deep plowing is to keep the roots down in the soil, so they will not come into the surface soil and suffer for moisture during the dry spells of the year. After plowing give careful cultivations at frequent intervals during the growing season of the tree, which is from the time the growth starts until well into July. During dry spells of the growing season, the cultivation should be very frequent and shallow from two to three inches, so as to maintain a fine dust mulch to prevent as much of the evaporation as possible.

The principal reason for cultivation should be the conservation of moisture, aeration of the soil, and the destruction of weeds. Whether the latter is a very important feature of orchard cultivation or not, we believe every orchardist should take pride in having his orchard free from

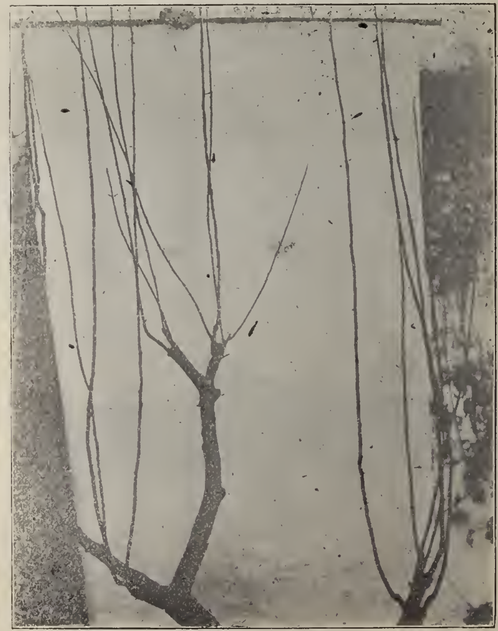

FIGURE 15. Showing the first seasons growth of a top worked three year old trees. (original)

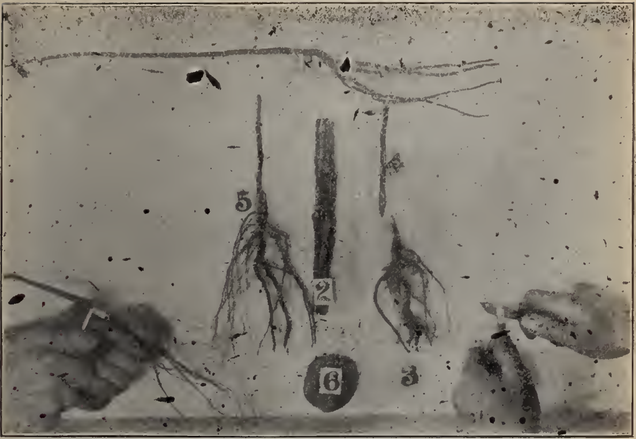

FIGURE 16. No. 1 shows a seedling apple stock. No. 2 a bundle of scions of a standard variety. The hand to the left is cutting away the top of the seedling stock showing the long slanting cut. The hand to the right is making the vertical cut in the stock. (original)

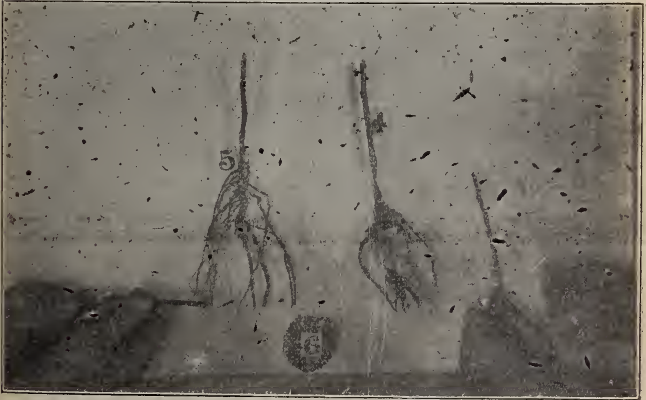

FIGURE 17. No. 4 shows stock and scion ready to be united. The hand to the left is shoving the stock and scion together, and the one to the right completing the graft by winding it with waxed cotton. No. 5 the complete graft. No. 6 a ball of waxed cotton. (original)

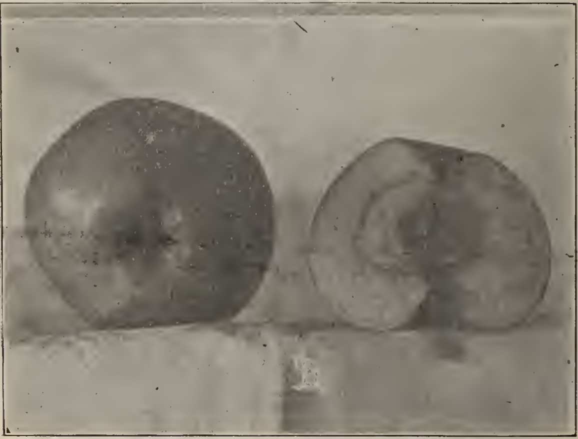

FIGURE 18. Yellow Transparent Fruit. (original)

weeds. We must remember that it takes plant food to grow weeds. Observation has made it very plain that the Maryland orchardist has not realized the full value of neat, tidy orchards free from weeds.

The soil should never be allowed to bake after a rain for want of cultivation for the moisture is rapidly evaporated from the hard smooth surface. In orchard cultivation one should use a harrow that leaves the ground smooth and fine as possible, for the larger the ridges the greater the evaporation surface , and the coarser the surface soil, the deeper will be the evaporation.

COVER CROP.

With the last cultivation in July some form of cover crop should be sown. The object of the cover is to have some vegetation upon the ground to prevent washing by fall and winter rains, and to add vegetable matter to the soil. This addition of vegetable matter will help the soil to retain more moisture, and to be easier of cultivation for it helps a stiff soil to become lighter and a light soil to become firmer. The best cover crops are those from leguminous plants, such as, cowpea, crimson clover, and alsike clover, etc. This class of plants not only add vegetable matter to the soil, but they also have the power by the means of tubercles on the roots to take up nitrogen from the air and store it in the soil for the use of the trees. When cowpeas are used some of the larger varieties, as Unknown or Wonderful should be used for the small kinds do not give stem growth enough. Sow cowpeas at the rate of one bushel to the acre.

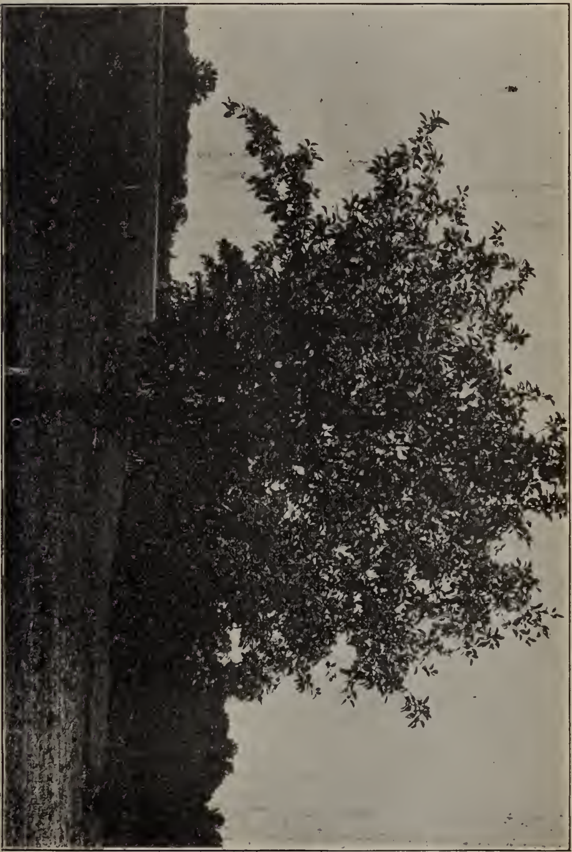

FIGURE 18. Yellow Tranaparent Tree. (original)

Crimson clover sow at the rate of twenty pounds per acre and alsike clover at the rate of ten to twelve pounds per acre. Of the non leguminous plants rye and oats are the best and should be sown at the rate of one bushel per acre.

When any crop that lives over winter is sown, it is usually best to plow* it under early rather than allow it to even partially mature. They should never be left to ripen their seed for then they draw too heavily upon the soil moisture.

*Sometimes these crops can be worked into the land by means of a disc harrow more economically than by plowing and at the same time keep the land more nearly level and prevent injury to the roots of the trees and washing of the land.

THINNING OF APPLES.

This question has never been given the thought and consideration in this State that it deserves. Many people consider it only a waste of time, but men in other States who have given the matter a careful test find it pays a good profit. For it lessens the culls and number two grades of fruit and increases number one grade of fruit. The strain upon the trees is not so great so they do not exhaust themselves, and are able to bear more regularly. The practice also largely prevents the trees from splitting and breaking to pieces when heavily loaded. The plan found to be the most successful is to thin each cluster to one or two fruits, when the little apples are the size of walnuts. See Fig. No. 10.

GRAFTING.

Grafting is a very simple operation and anyone can succeed with it by using ordinary pains and care. There are a number of different methods of grafting, but the ones that interest the apple growers are the whip or root graft, and the cleft and side graft. Cleft grafting is the method used for large trees where the limbs are three-fourths of an inch and more in diameter. See Fig. 11. For smaller limbs use the whip graft, upon the top of the tree just the same as for making root grafts, and wrap them with strips of cloth. In grafting a tree select the branches for grafting that are as erect as possible, for if horizontal branches are used the grafts will grow erect and make an ill shapen tree. See Fig. No. 12. Cut the branches off square and split the stub with an ordinary grafting chisel just enough to insert the scions on the outer edge so that the bark of the graft will come in contact or cross the bark of the limb in which the graft is set. These grafts should be from four to five inches long containing three or four buds. Cut the graft wedge shape with the edge entering the limb the thinnist so that the pressure of the split will hold it in place.

Be sure and have one bud on the lower end of the graft so as to come under the wax. In limbs an inch or more in diameter it is a good plan to insert a graft upon each side and then if both live, the weakest one can be cut off. After the grafts are set the whole cut surface of the limbs and the opening caused by the splitting of the limbs should be carefully covered with grafting wax. The grafts should be well ripened wood of the present year's growth. The side graft can be used upon young trees that have been headed too high and we wish to have limbs lower down on the trunk. See Figs. 13 and 14. It is done by cutting a slit in the trunk where we want the limb and then cutting a wedge shaped graft to fit the opening in the trunk and carefully binding the graft in place by waxed cotton and covering the whole exposed surface with grafting wax. The scion should be from three to four inches long.

Top graftng or top working is a method used where all of the top of the tree is removed and grafted to some other sort. This method is used upon young trees from two to five years old. The whip graft method is the best one to use, but very satisfactory results can be had by using the side graft as will be seen by illustration from Mr. Chas. Sweet's orchard, Swanton, Md. See Figs. 13 and 15. On young trees it is possible to use both the whip graft and the cleft graft methods to good results. After the tree becomes older it is not a good plan to remove all the top at once, but only part of it one season and the balance the next season, and gradually remove the limbs that are not wanted until a new top is formed, for it will be too much of a shock to an old tree to remove the whole top during one season.

GRAFTING WAX.

There are a number of different kinds of waxes used, but the following one will be found good for all purposes. Resin 4 parts by weight, beeswax 2 parts, tallow 1 part. It is made as follows; Break the material up into small pieces and melt together, and when all melted and very hot pour into a pail of cold water and then pull and work over until it becomes tough and gets a grain." It is then ready too use and should be applied to the tree in a warm state so that it will handle well. The hands should be kept well greased.

ROOT-GRAFTING.

Apple trees at the present time are nearly all propagated by using root-grafting, sometimes known as the whip or tongue method of grafting. In making root-grafts, the stock or part that forms the root is a small one-year seedling grown from apple seed. These stocks can be had from any leading nurserymen. The scion is the part that forms the top. It should be well ripened, one-year old wood of the variety from which we want to obtain trees. In making the root-grafts, both the scion and the stocks are cut across diagonally with a long slanting cut, the cut surface extending from three-fourths to one and one-half inches according to size of parts. A vertical cut is then made in the cut surface of both the stock and the scion and the two are joined together by shoving the tongue of the scion into the cleft of the stock. This method can be much better understood by noting the illustration under figures number 16 and 17. In making the grafts care should be taken to have both the stock and scion as near the same size as possible, so as to have the edges of the bark come close together. The parts of the grafts are held in place by some soft bandages that will soon decay, such as strips of paper covered on one side with grafting wax, or balls of white darning cotton soaked for fifteen minutes in hot grafting wax. The two parts of the graft are held in place by winding them five or six times with this waxed cotton. This cotton is strong enough to hold the parts of the graft together until they have united. The time for making the grafts is during the winter from

January to March. When made, the grafts are tied in bundles and packed in damp moss or sawdust and put in a cool place until spring.

If well made there will be no trouble in having the two parts calloused together. Whole root grafts are those in which the union is made at crown of the stock so as to have the whole root or stock. This kind of a graft is very seldom made though frequently advertised to be so. The common method is to make what is known as "piece root-grafts," in which the root of the stock is cut up into pieces from three to four inches long, and a scion grafted upon each of these pieces. The scion should contain at least three or four buds and be four or five inches long. This makes the whole graft from seven to ten inches long. Apple can also be very successfully budded during the month of August.

HOW TO IMPROVE VARIETIES.

This is a very important question and should be given much more consideration by apple growers than it is at present receiving. There are several points to be discussed under this heading, and in the first place consider the question of varieties from other sections. There is always a tendency to get the varieties that are successful in some other sections especially from the leading apple districts of the North and West. In nearly every orchard in this State is seen evidence of this method of securing varieties, for few of those from distant sections are successful in this State. It is useless to plant for commercial purposes such varieties as Baldwins, Greenings, Northern Spy, Thompkins King, etc., for they will not succeed. The season is too short and the soil, and climatic conditions are not to their liking. What is true of the varieties mentioned is true of practically all others from the north and west. There is some times a chance of obtaining valuable varieties from sections having as nearly the same climatic and soil conditions as our own State. But our principal success for obtaining new and improved varieties is in selecting,

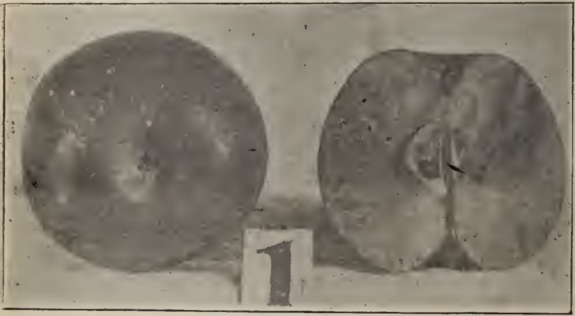

FIGURE 20. American Summer Fruit. (original)

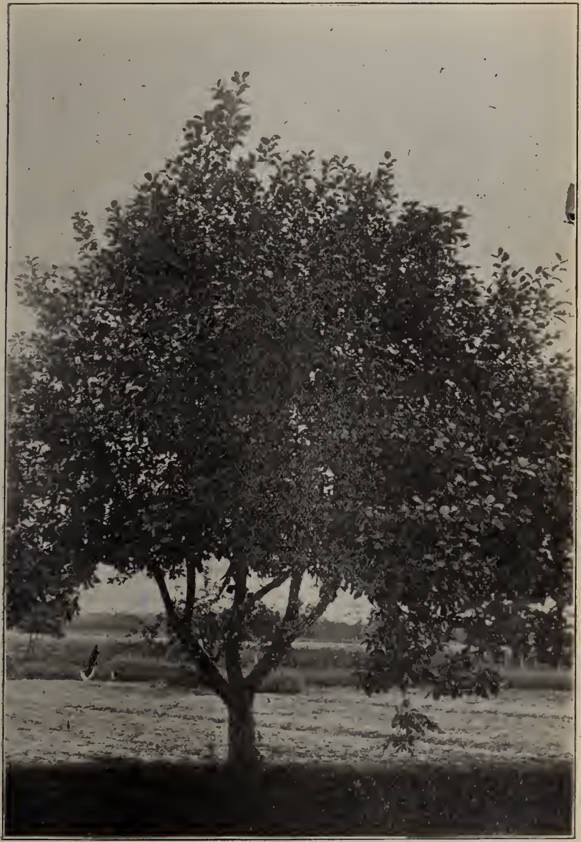

FIGURE 20. American Summer Tree. (original)

improving, and disseminating the native seedlings of which there are very many promising ones. The sections in which these local sorts succeed must be determined, and they must be named and propagated so that they can be had by every one who wants them for planting. The question of the extent of territory over which a variety is successful, is also an important one, for we find very few cosmopolitan varieties. Because a variety is a success in the Blue Ridge Mountains does not indicate it as being a success in the Eastern part of our State. A variety may be very successful in one neighborhood and a total failure a few miles distant. This question of selecting varieties adapted to your section should be given very careful consideration for it is one of the fundamental points of successful apple culture.

Description of varieties of apples grown on the Maryland Station grounds. This list is given in order of ripening under the head of summer, fall and winter varieties.

EARLY SUMMER VARIETIES.

Yellow Transparent. Tree small, erect, and a very slow grower, a very early and prolific bearer; fruit small to medium; roundish; color light whitish yellow, with a slight splash of russet around the stem; skin very smooth, and tough; cavity broad and deep; basin broad and medium shallow; stem long and heavy; flesh whitish yellow, crisp, tender, and juicy; flavor subacid, pleasant; season last of June and first of July. This variety comes into bearing very young, frequently bearing some fruit the second or third year after setting in orchard. It does well in this State, and should be extensively planted for home use.

2. Carolina Red June. (Red June, Blush June). Tree strong and vigorous, very erect in habit of growth. Fruit small, oblong; color green-

FIGURE 21. .Chenango Strawberry Fruit. (original)

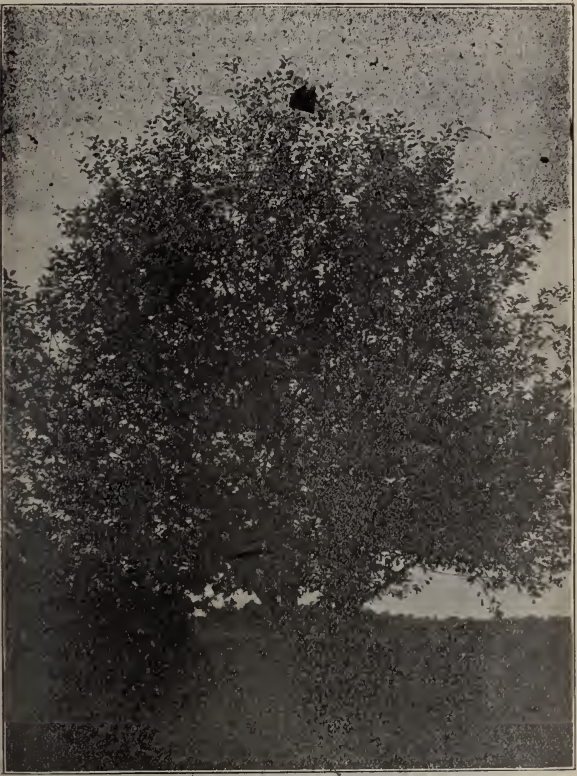

FIGURE 21. Chenango Strawberry Tree. (original)

ish almost covered with full deep red, minute white specks around apex; stem medium long; cavity narrow and deep; basin very shallow and broad almost wanting; skin tough; flesh greenish white, tender, rather buttery, flavor subacid only fair; tree productive; very early bearer; season of ripening last of June and first of July. A variety that has little to recommend it for general planting in this State.

3. Early Ripe. Tree strong, vigorous, medium erect, a handsome grower; fruit medium sized, round, oblate, flattened at ends; color yellowish, has a rusty pot around stem; cavity broad rather deep; basin broad and verv shallow; stem short and stout; flesh yellowish white; firm; crisp; flavor rich, subacid, very good. Season July first to fifteenth, tree a prolific bearer. A very valuable early apple for both home and market purposes. This sort is at home in this State and should be more largely planted.

4. Early Harvest. (Yellow harvest, Prince's Harvest, July Pippin.) Tree a vigorous and spreading sort; fruit medium to large, round somewhat oblate, color a bright waxy yellow with slight russety spot around the base, skin tough, stalks short and slender; cavity broad and rather deep; basin broad and rather shallow; flesh yellowish white; tender, crisp, and juicy; flavor slightly acid very pleasant. This is an old and popular sort from the Northern apple sections and where it does well it is fine for the home garden.

5. Red Astrachan. Tree very strong, hardy, and vigorouos, medium spreading, making a very handsome shaped tree; fruit medium to large, roundish oblate, color yellowish white almost covered with handsome bright red and entirely covered with a very pronounced beautiful bloom, skin smooth; basin broad and shallow; cavity broad and deep; stalk very short; flesh creamy white, tender, crisp and juicy, flavor acid, very pleas-

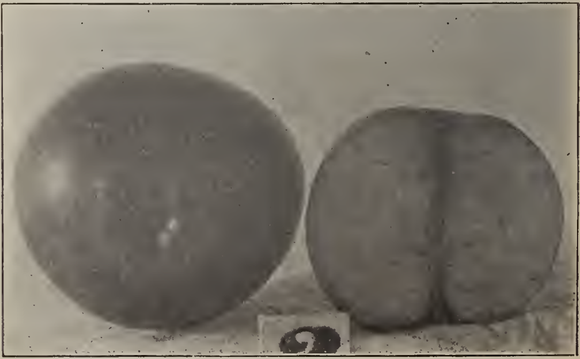

FIGURE 22. Bailey's Sweet Fruit. (original)

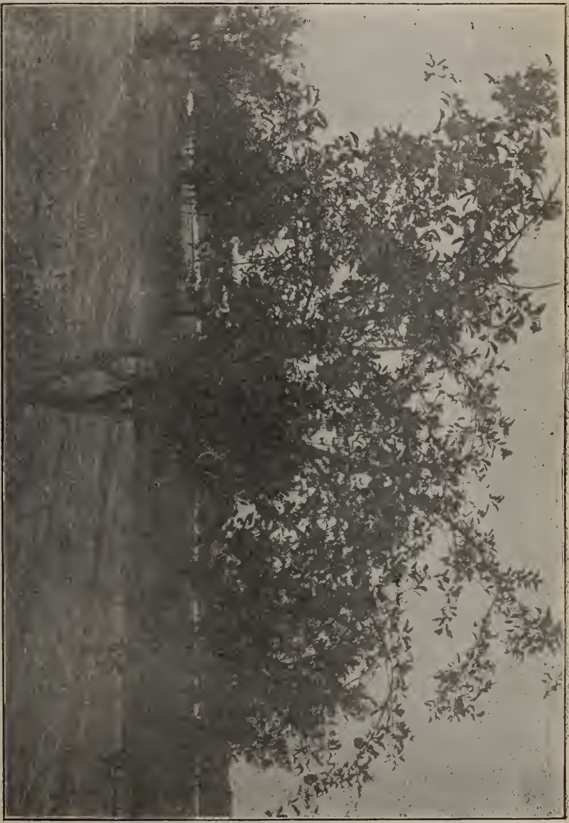

FIGURE 22. Bailey's Sweet Tree.

ant, a fine cooking apple. Season July first to fifteenth. This is another old popular sort from the northern fruit districts and succeeds well here.

6. American Summer. Tree small to medium, rather a weak grower; fruit roundish, slightly conical, somewhat inclined to be one sided in shape; color greenish yellow with dull reddish brown cheek, the surface of the skin covered with small yellowish white specks, skin rather rough and giving a very poor appearance to the fruit; basin shallow and broad; cavity broad and deep; stem slender three fourth to one inch long; flesh creamy white, very tender, crisp, and juicy until very ripe when it becomes mealy; flavor subacid, rich, excellent, one of the best in its season; season last of July to first of August; a productive sort, and one of especial value for home use, but the fruit lacks color and appearance to make a profitable market growing. See Fig. 20.

7. Chenango Strawberry. (Frank Buckley, Jackson, Sherwood's Favorite.) Tree very large and strong grower, erect and productive; fruit medium to large, round, long, conical; color yellowish white, striped and splashed with red, skin smooth and waxy, making an apple of very handsome appearance; flesh white, tender, juicy, flavor slightly acid of only fair quality; basin broad and shallow; cavity narrow and deep; stem about one half inch long; season from last of July to first of August. A promising sort for commercial growing. See Fig 21.

8. Benoni. Tree small, compact grower, erect; fruit small to medium, roundish and somewhat conical; color yellowish with reddish stripes and splashes over surface; skin smooth and tender; basin broad and shallow, cavity narrow and deep; stalk short, one-half inch long; flesh yellowish, very tender, juicy sub-acid, rich, melting; very high quality; season last of July to first of August. This sort is usually not very productive, but where it succeeds, it is one of the choicest sorts for the home garden.

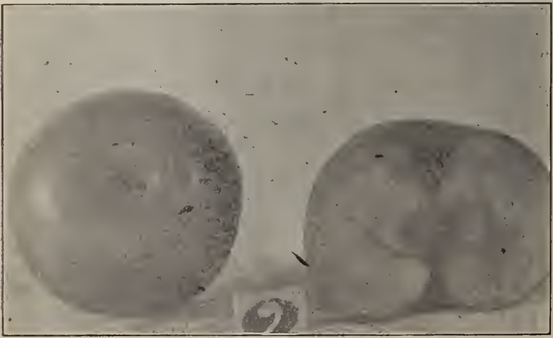

FIGURE 23. Jefferies Fruit. (original)

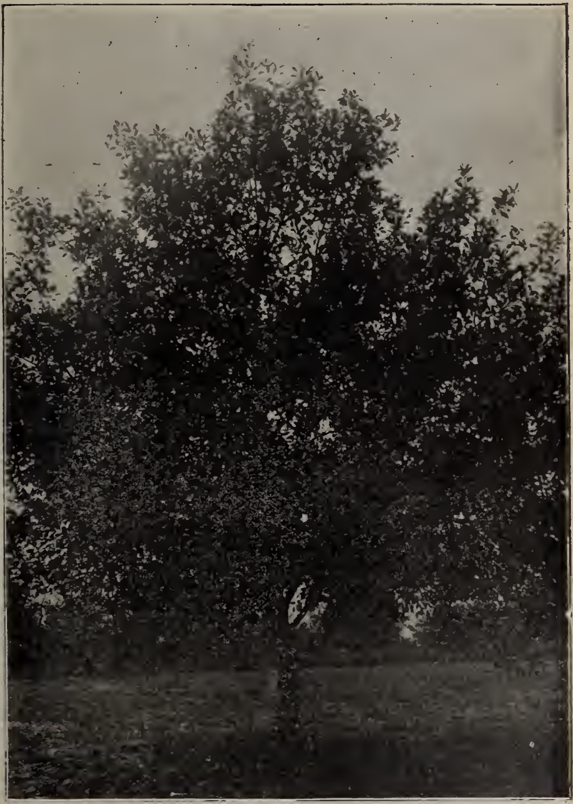

FIGURE 27. Jefferies Tree. (original.)

LATE SUMMER AND FALL VARIETIES.

No. 9. Bailey's Sweet. (Patterson's Sweet, Edgerly Sweet,). Tree a small, slow grower, not hardy and vigorous, rather spreading; fruit large to very large, round ovate; color yellowish green almost covered with indistinct red stripes and splashes, minute white specks over surface, coloring much heavier at base; basin shallow and broad, cavity narrow and medium deep; stalk one half to three fourths of an inch long; a very handsome apple; flesh greenish white, firm, tender; flavor, sweet, pleasant; a very productive sort, ripening from the middle of August to the first of September. An especially fine summer sweet apple for home garden. See Fig. 22.

10. Gravenstein. Tree hardy, strong, and vigorous, fruit medium to large, roundish somewhat oblate; color yellowish, striped and splashed with red; flesh yellowish white, tender, crisp, and juicy; flavor slightly acid, very pleasant. High quality; season latter part of July and first of August. It has not been productive with us here, but in many sections of the State, it is quite productive. It should be included in every home orchard.

11. Jefferies. Tree a large strong grower, medium erect; fruit medium to large, round oblate, color yellowish white, striped and splashed with red when exposed to the sun nearly a full red side, brownish dots over the surface of skin; skin slightly rough and tender; flesh yellowish white, tender, crisp and juicy; flavor subacid, very rich, and apple of very high quality and exceedingly pleasant to eat out of hand; basin broad and shallow; cavity narrow and deep; season first to middle of August; a pro-

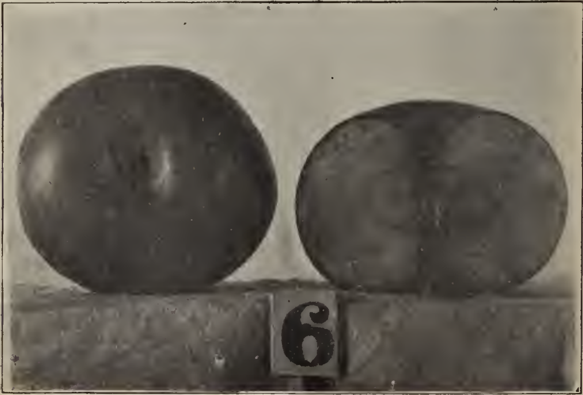

FIGURE 2. Maryland Maiden Blush Fruit. (original)

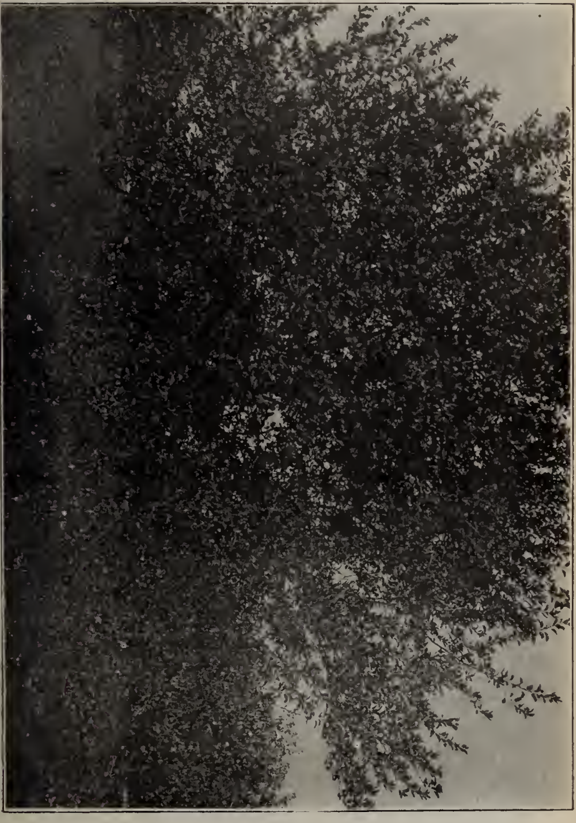

FIGURE 24. Maryland Maiden Blush Tree, (original)

ductive sort. This is an especially fine variety for desert purposes and should be in every home garden and commercial orchard for it is at home in this State. See Fig. 23.

12. Summer Rambo. (Western Beauty). Tree very hardy, vigorous, and medium erect; fruit large to very large, round flattened; color yellowish white shaded with bright red; basin very broad and shallow; cavity medium broad and deep; flesh yellowish white, very tender, crisp, juicy; flavor sub-acid, very pleasant; season last of August to first of September. An old sort but not very prolific in this section.

13. Maryland Maiden Blush. Tree a strong vigorous grower, rather spreading; fruit round oblate, medium to large; color creamy white with a very delicate red cheek, skin very smooth and tender, cavity wide and deep; basin broad and shallow; flesh creamy white, tender, crisp, and juicy; very fine grained; flavor sub-acid, melting, very pleasant, one of the best in its season, season last of August and first of July. This is an old variety and is at home in this State, but is usually lacking in productiveness, but on account of its excellent qualities, it should be included in the home garden. See Eig. 24.

14. Fall Pippin. Tree a strong and vigorous grower, of spreading habit, very compact; fruit large to very large, roundish oblong; color a deep handsome yellow when fully ripe, skin very delicate, smooth and waxy; flesh yellowish white, very tender, juicy; flavor sub-acid, rich, melting, very pleasant, basin deep and very broad; cavity narrow and deep; season first to middle of September. A variety that is native of the north and not productive enough for planting in this State.

FIGURE 25. Grimes Golden Fruit. (original)

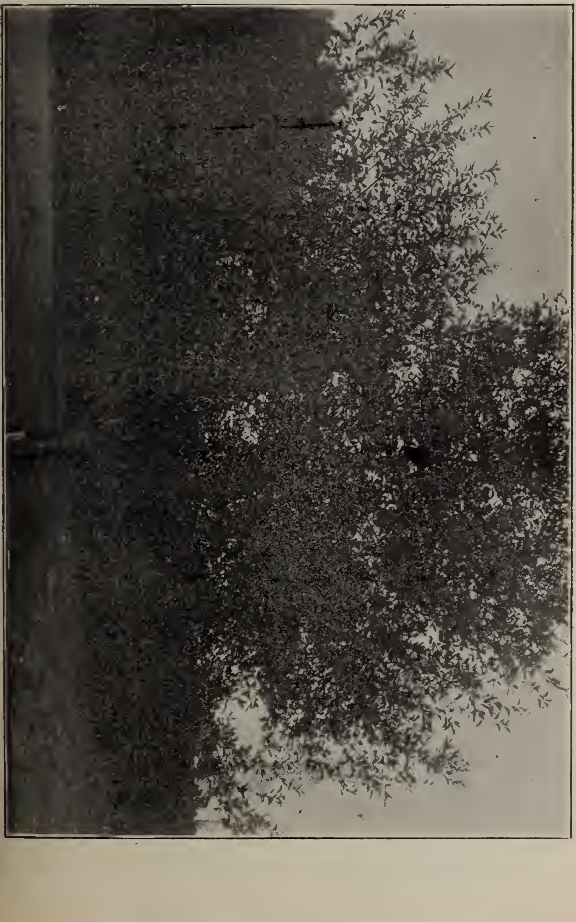

FIGURE 25. Grimes Golden Tree. (original)

15. Buckingham. (Bachlor, Equinetely, Kentucky Queen). Tree erect, rather a poor grower; fruit large to very large, round somewhat flattened; color greenish yellow nearly covered with red stripes and splashes; basin broad and deep; cavity broad and deep; stalk stout; flesh yellowish white, tender, juicy, and crisp; flavor slightly acid, high quality, very pleasant; season September. A very productive sort and one that should be more generally planted for early fall use.

16. Winter Rambo. Tree large, strong, and vigorous, medium erect; fruit medium, round, flattened; color greenish yellow, striped and splashed with dull red; stalk one half to three fourths inch long; flesh white, tender, and juicy; flavor sub-acid, fair; season first of October. The fruit is of very poor appearance, and soon after ripening becomes dry and mealy. A very productive sort but not profitable for planting when we have so many other varieties that are better.

LATE FALL AND WINTER.

17. Grimes Golden. Tree somewhat spreading, fairly hardy and vigorous, fruit medium to large, roundish oblong; color handsome pale yellow when fully ripe; flesh yellowish white, fine grained. tender, juicy; flavor sub-acid, rich; a pleasant apple of very high quality; basin broad and deep; cavity deep; season September. A very productive variety and one that is thoroughly at home in this State and should be extensively planted for both home use and commercial growing. It is not a long keeper, being at the best from October until Christmas unless placed in cold storage, when it can be carried until January or February. Persons in the Northern and Western parts of the State, who are considering planting an apple orchard, should give this variety careful attention. See Fig. 25.

18. Stark. Tree hardy, vigorous, medium spreading; fruit medium to large, round flattened, color greenish yellow, splashed and slightly striped with dull red upon side exposed to the sun; basin broad and shallow, cavity broad and deep; stalk slender, three fourth to one inch long; flesh greenish white, coarse grained, juicy; flavor slightly acid, rather poor; season September and early fall, matures too early to have commercial value in this State, and lacks quality for home use. Usually quite productive.

19. Kinnaird. (Kinnaird Choice) Tree a strong, vigorous grower, branches very slender and drooping; fruit round oblate, medium size; color yellowish red, becomes a deep full dark red when exposed to the sun; has minute brown dots over the surface of skin; flesh yellowish white, tender, crisp, juicy; flavor slightly acid, good, very pleasant; a very productive sort, long keeper, and early bearer. A very promising apple of Southern origin. See Fig. 26.

20. Smoke-house. Tree a strong, hardy and vigorous one, fruit medium, round oblate; color yellowish white slightly striped and splashed with red; flesh yellowish, tender, juicy; flavor, sub-acid, rich, a very productive sort, not a long keeper; fruit at its best during late fall and early winter. Its good size and handsome appearance make it a popular sort, succceeds well in this State.

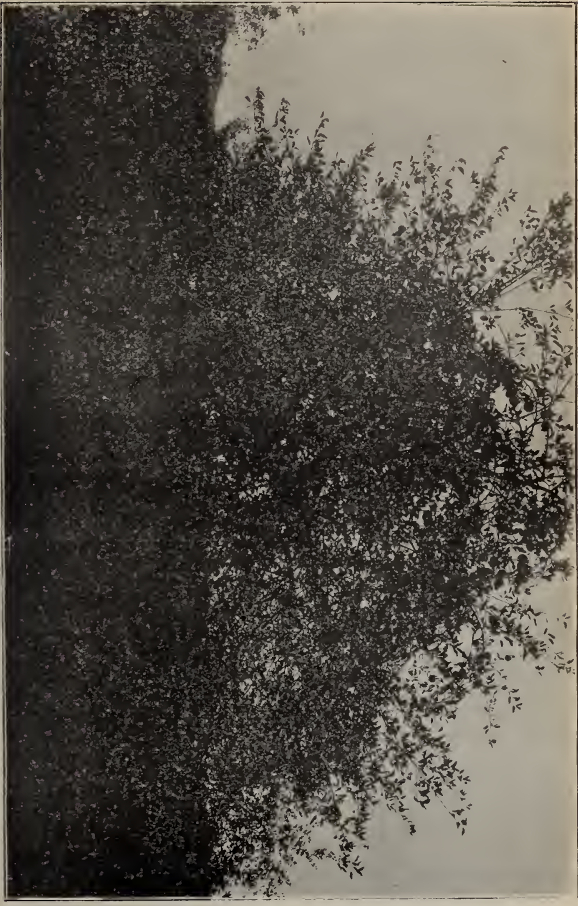

FIGURE 26. Kinnard Tree, for picture of fruit see "Branch of Kinnard", page 1. (original)

21. Langford Seedling. Tree not hardy and vigorous with us; fruit medium to large, round oblong, somewhat flattened at ends, color yellowish nearly covered with full deep red; basin broad and deep, cavity narrow and deep; flesh yellowish white, tender, juicy; flavor sub-acid, pleasant; a productive and long keeping variety. A native of this State and succeeds well in southern and eastern sections.

22. Stayman's Winesap. Noted from Mr. J. W. Harris's orchard, Coleman, Md. Tree vigorous and hardy of the winesap type; fruit medium, roundish and somewhat conical; color, yellowish, almost covered with two shades of alternating stripes of red, skin smooth; flesh white, tender, crisp, juicy; flavor sub-acid, very good; a long keeper. On account of its bright red color, good size, and high quality, this sort should be extensively planted. It is at home in this State and especially upon the higher lands of the tide-water region. Mr. J. W. Kerr the veteran nurseryman, says of this sort, "Its quality is equal to that of any other apple with which I am familiar, and superior to ninety-five per cent of them."

23. York Imperial. (Johnson Fine Winter). Noted from the orchard of Mr. S. S. Stouffer of Sharpsburg, Md. Tree a large strong grower, rather erect; fruit medium to large, round oblong, usually lopsided; color yellowish shading to red, and covered with indistinct red stripes, skin smooth, tough, covered with rather prominent yellowish brown dots; cavity deep and rather narrow; basin broad and deep; stalk very short; flesh yellowish white, firm, juicy; flavor sub-acid, good but not of high quality. A long keeper and the fruit is not at its prime until the latter part of winter and spring; tree very productive, one of the lead-

*FIGURE 27. York Imperial Fruit. (original)

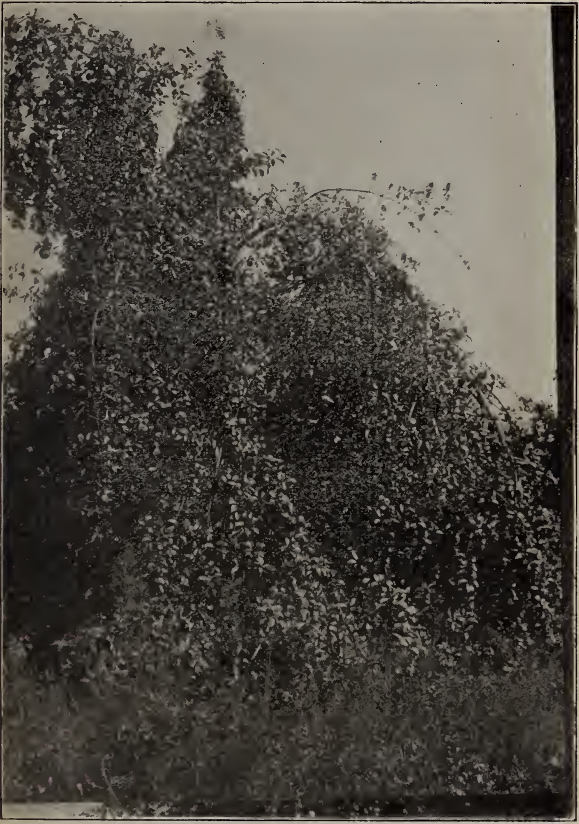

FIGURE 27. York Imperial Tree. (original)

ing commercial varieties of the State. This sort has good color, fine shipping and handling qualities. See Fig. 27.

24. Smith's Cider. Noted from same orchard as former. Tree a strong hardy grower, erect; fruit medium, roundish oblong with ends somewhat flattened; color a greenish yellow, striped and shaded with red, and when well exposed to the sun, becomes a very handsome apple. Skin smooth, tough, covered with very minute whitish dots; cavity deep and narrow, basin broad and shallow; stalk long and slender, flesh whitish, tender, crisp, juicy flavor; sub-acid, very pleasant; a long keeper, but it is at its prime during late fall and early winter, for after middle of winter it looses its flavor and becomes somewhat mealy; it is very productive and a leading commercial variety for this State. See Fig. 28.

25. Fallawater. (Tolpahacken, Farmwalder). Tree a strong hardy grower; fruit large to very large; roundish and somewhat conical; color greenish yellow, with a dull red side when exposed to the sun, skin smooth, with a few very prominent whitish dots; stalk slender; cavity narrow and deep; basin small and shallow; flesh greenish white, tender; flavor sub-acid, good. Not a long keeper and the fruit is at its prime during fall and early winter. This variety succeeds well in this State and the large size and good appearance of fruit make it popular for both home and commercial growing.

List of varieties recommended for planting in Maryland for home orchard. Early Summer varieties. Yellow Transpareunt, Early Ripe, American Summer, Benoni.

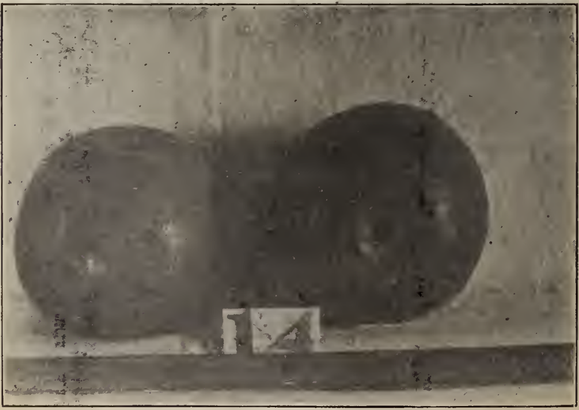

FIGURE 28. Smiths Cider Fruit. (original)

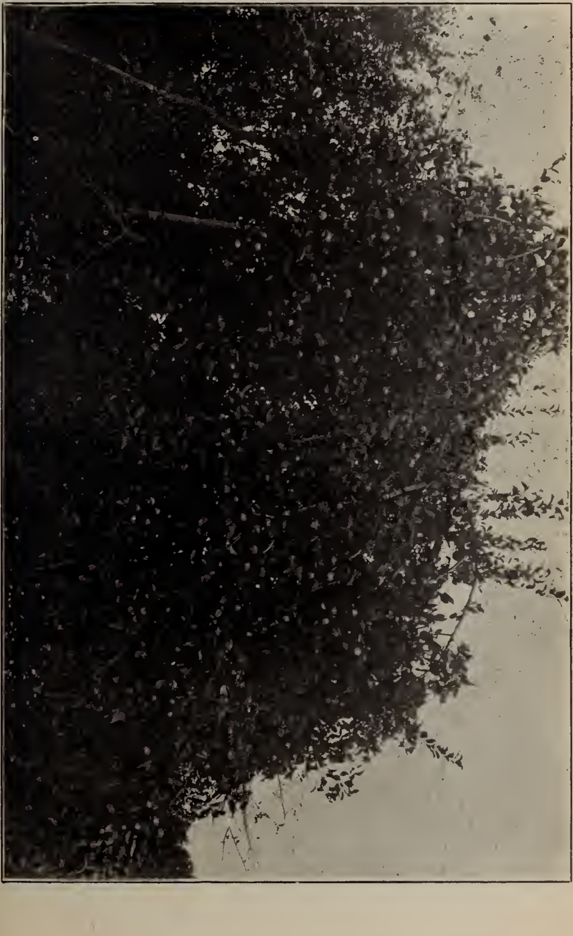

FIGURE 28. Smiths Cider Tree. (original)

Late summer and fall varieties: Bailey's Sweet, Gravensteins, Jefferies, Maryland Maiden Blush, Buckingham.

Late fall and winter varieties: Grimes Golden, Kinnaird, Smokehouse, Stayman's Winesap, Smith's Cider, Fallawater, York Imperial.

Commercial orchard.

Early summer varieties: Yellow transparent, Early Ripe, Chenango Strawberry, Benoni.

Late summer and fall varieties: Gravenstein, Jefferies, Buckingham.

Late fall and winter varieties: Grimes Golden, Stayman's Winesap, Smith's Cider, York Imperial.

The Horticultural Departmnt will be glad to receive scions of promising new varieties for testing.

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*Photographs for figures twenty seven and twenty eight were taken from orchard of Mr S. S. Stouffer, Sharpsburg.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 93. May, 1904.

SECOND REPORT ON THE CAUSE OF PITHINESS IN CELERY.

By C. F. Austin and Thomas H. White.

INTRODUCTION.

For a number of years the Experiment Station has been doing a considerable work with celery to determine, if possible, the cause of pithiness. A preliminary report of this work, together with the general notes on celery culture, was published as bulletin No. 83 by Prof. E. P. Sandsten and Thomas H. White. Copies of this bulletin are still available and should be read in connection with the present report. During the past two seasons further work has been done with this subject and the results are given in the following pages.

The work for season of 1902 was along lines already indicated in the "First Report." The seed was selected from six of the leading seed firms in this country and Europe. One set of plants was grown in rows, see table 1, and one set grown in solid beds, see table II. The plants grown in the rows were started in the forcing house, seed sown March third, plants pricked out into cold frame April 20th, and set out into the field June 30th.

The plants for the bed were sown out of doors March 22nd., and when well started they were thinned out to two inches apart. The plants were set in the solid beds July 19th. The location of the celery beds was upon a plot of flat land which was in a very good state of fertility. The soil was rather heavy containing a good per cent of clay and gravel.

Before discussing the results given in tables 1 and II, we wish to call attention to the following:

First. Practically all of our work has been done with the variety known as Golden Self Blanching, where other varieties have been used, the names have been given. We have used the Golden Self Blanching because it is the variety largely grown by our truckers in Maryland. It also represents the type of varieties that have been bred up to a high state of perfection.

Second. A stalk has not been counted pithy unless the whole stalk, the heart as well as the outer part, has been pithy. When the three or four outer stems have been somewhat pithy and the heart solid, the stalk has been counted as solid.

Third. In this report we have kept an account of the number of green plants and in the tables have put them under the heading of "Number of green plants." Under this head has been put all plants that come fully green and do not conform to the type of the Golden Self Blanching variety. In a few instances the green plants have been a mixture of some of the other varieties as White Plume, etc. Almost invariably these green sorts have been large green coarse growing plants which do not conform to the types of any of our varieties of cultivated celery. They seem to be a degenerate form of the type and the first steps in the reversion to the wild species. These plants are as objectionable or even more so than a pithy stalk which does conform to the type.

TABLE I.

Plants set in rows season 1902.

Variety.	Seedsman.	No. Plants set.	No. Plants harvest'd	No. Plants Pithy.	No. Plants Green.	Per Cent Pithy.	Per Cent Green.
Golden Self Blanching	A's American	100	100	15	1	15	1
"	B's American	93	93	2	0	2.15	0
"	C's American	68	68	1	3	1.4	4.4
"	D's American	37	37	0	0	0	0
"	E's French	100	100	0	0	0	0

TABLE II.

Plants set in beds. Season 1902.

Variety.	Seedsman	No. Plants Set.	No. Plants harvest'd	No. Plants Pithy.	No. Plants Green.	Per Cent Pithy.	Per Cent Green.
Golden Self Blanching	A's American	65	65	5	0	7.6	0
"	B's American	50	50	0	0	0	0
"	C's American	20	20	1	2	5	10
"	E's French	60	60	0	0	0	0
"	*F's German	100	100	50	0	50	0
White Plume	E's French	100	100	0	0	0	0

F's seed was from a leading firm in Germany. The seed arrived too late to be planted in the early lot in rows, but one hundred plants were put into the beds. This was very poor seed and showed scarcely any of the characteristics of the Golden Self Blanching stock from Velmorin-Andruex & Co., of Paris.

The color of leaf stalks and foliage was more green than yellow, and the plants resembled very closely in every detail, the plants we raised here at the Station grounds from seed of a pithy stalk of Golden Self Blanching. The firm made the following report as to where they got the seed. "The seed has been grown for us in the northern part of France separately, on a field along-side of "Best Egyptian Flat Dark Red."

A careful study of tables I and II will show that the different methods of growth made no great difference in the amount of pithiness of the American seed, while the French seed is as usual free. In table II is a sample of the French seed of both Golden Self Blanching and White Plume. The condition under which the plants were grown does not seem to affect this cause. Our former work gave many indications that pithiness was the beginning of the breaking down of the type and of the reversion to the wild state. To test this farther some seed was saved from both pithy and solid stalks with the following results.

A typical stalk of the Golden Self Blanching variety that was completely pithy was secured and seed raised from it during the season of 1901. The seed was sown in the spring of 1902 and handled just the same as the plants in the rows. From this seed twelve plants were raised and in the fall every plant was pithy and eleven of the twelve plants developed into large coarse growing, green plants. See table III. The eleven large green plants gave no resemblance whatever to the type of the Golden Self Blanching celery from which the seed was taken. During the same year seed was saved from a solid stalk and from a pithy stalk of Dwarf Golden Heart. From the seed of the solid stalk fourteen plants were started and twelve harvested. The twelve plants were true to the type and free from pithiness. From the pithy stalk, twenty plants were raised, and everyone pithy. They showed as decided reversion of type as the plants from the pithy seed of the Golden Self Blanching variety. Many of the plants from the pithy seed showed the fine parsley like foliage so common in the wild species.

TABLE III.

Plants grown from pithy and solid stalks. Season 1902.

Variety.	Seedsman.	No. plants set	No. plants harvest'd	No. Plants Pithy.	No. plants green.
Golden Self Blanching seed from pithy stalk	Horticultural Department of Md. Agr. Exp. Sta.	12	12	12	11
Golden Heart, seed from solid stalk......	"	14	12	0	0
Dwf. Golden Heart, seed from pithy stalk......	"	20	20	20	0

After giving this matter careful study there seems to be no doubt but that pithiness in celery is due to the parent plant, and not to any extent to the soil, methods of culture etc. We believe that the foregoing results fully prove the inference made in bulletin 83, that pithiness in American celery is due to a lack of "rogueing" or removing of the pithy plants from the seed beds of American celery seed growers. We also believe that green plants that are not true to the type are caused by the same oversight, namely, by not removing from the seed beds every plant that does not conform to the type of Golden Self Blanching celery. From a very small amount of work with several other varieties of celery we are convinced that what is true of the Golden Self Blanching is true of them. The cause of pithiness is hereditary, and dates back to the seed producing plant. The difference in soil, cultivation, season, methods of handling, etc., has very little to do with causing pithiness. The seed is contaminated before it reaches the grower, by a condition that he cannot help.

The work for the season of 1903 was to test a sample of Golden Self Blanching celery seed, both French and American grown, from as large a number of seedsmen in this country and in Europe as we could obtain the seed. The seed firms were asked to tell us whether the sample of seed was French or American grown and, if possible, to send a sample of each. A large number of the firms followed our request by giving as far as possible, the place where the seed was grown. We have placed them in tabular form just as given us as French, European, American or California grown. Some firms sent seed but did not answer questions and these in the table have been given a simple dash. See table IV.

TABLE IV.

Showing the Relative Amount of Pithy and Green Celery Produced from Different Sources.

Golden Self-Blanching Variety.

Seedsman.	Where seed grown.	No. plants set.	No. plants harvested.	No. plants pithy.	No. plants green.	Per Cent pithy.	Per cent green.
J. M. Thorburn & Co.	France	90	77	0	0	0	0
	American	100	90	4	1	4.4	1.1
Henry Phillips Seed and Implement Co.	France	100	95	0	0	0	0
	American	100	92	5	7	5.3	7.6
Hastings Seed Co.	European	100	88	1	1	1.1	1.1
	American	100	85	1	10	1.2	11.7
Vilmorin Andrieur & Co., Paris	France	100	91	0	0	0	0
James Carter & Co. (London)	European	50	47	4	1	8.5	2.1
Livingston Seed Co.		100	92	1	1	1.0	1.01
Peter Henderson & Co.		100	96	0	4	0	4.1
John A. Salzer Co.	California	100	95	25	1	26.3	1.4
Vaughn Seed Store	European	100	86	26	2	30.2	2.3
J. G. H. Gregory & Son		90	82	0	2	0	2.4
Wm. Rennie Seed Co.	France	100	95	0	0	0	0
The Storrs & Harrison Co	France	100	93	1	3	1.07	3.2
W. W. Rawson Co.		90	68	0	2	0	2.9
Iowa Seed Co.		90	60	0	14	0	23.3
Ford Seed Co	France	90	65	1	6	1.5	9.2
Henry A. Dreer	France	100	100	0	10	0	10
	California	100	77	3	0	3.8	0
L. L. Olds Seed Co.	France	100	100	5	0	5	0
R. J. Farquhar Co.	France	100	91	0	0	0	0
H. N. Hammond Co		100	62	15	0	24.2	0
J. Steckler Seed Co.	France	90	86	13	0	15	0
D. Landreth Co.		100	81	0	1	0	1.2
T. W. Wood & Son	France	100	88	6	3	6.8	3.4
	American	90	81	1	0	1.2	0
Johnson & Stokes	France	100	74	0	1	0	1.3
	American	80	55	11	0	20	0
Wm. Henry Maule Co		70	62	0	4	6.4	0
Currie Bros. Co	France	20	18	0	0	0	0
	California	90	62	0	15	0	24.2
P. V. Burrells		70	59	1	2	1.6	3.2
W. At'ee Burpee Co.	France	100	100	0	0	0	0
	American	100	67	0	1	0	1.4
Griffith & Turner		100	83	0	6	0	7.2

The European firms sending seed were: Velmorin-Andreux & Co., Paris, France; James Carter & Co., London, England; Haage & Schmidt, Erfurt, Prussia. Velmorin-Andreux & Co's seeds, as in all previous tests we have made, was absolutely pure, being free from pithy and green stalks. The plants from James Carter & Co., had much the same appearance as did the plants from American grown seed in the years 1899 and 1900. (See Bulletin No. 83.) There were four pithy and one green stalk out of forty-seven harvested. Some of the plants had the parsley like foliage, so characteristic of the pithy plants. The seed from Haage & Schmidt, arrived too late to go in the test for this season.

Reference to the table and to Bulletin 83 will show that the per cent of pithy stalks in American grown seed is very much less the past two years than in the years preceeding. The parsley like foliage has also disappeared with pithiness, but there is, however, a large per cent of green stalks.

The small amount and narrow limit of our work, will perhaps, not justify us in making an absolutely correct statement as to what this change in the American seed is due. We think the cause of this less amount of pithiness can be accounted for by the fact that there has been considerable agitation of the question and the growers of American celery seed have been weeding out more of the pithy plants from their seed beds than formerly.

A careful study of table IV will show that there is still a great improvement needed in American celery seed in order to bring it up to the excellent standard of Velmorins.

The green stalks also must be eliminated for they are the cause of much loss. The extensive growers in Maryland are now growing Golden Self Blanching variety in rows. The earth is worked up to the plant with celery hillers. Late in the fall the plants being only partially blanched are stored in trenches in the field or in the cellars, etc. to finish the blanching process. Under such conditions the growers claim the green plants are entirely useless and have to be thrown away, as they will not blanch so as to become marketable under the same condition as the Golden stock.

It is surprising the number of green plants that come from some of the seed as sold upon the market. And to the green plants must be added the number of pithy ones, which make in some instances as high as twenty-five to fifty per cent of impurities and imperfections in the celery seed. To one who is familiar with both the American and French seed, there is exceedingly strong indications that some of the celery seed sold for French stock contains from fifteen to forty per cent of American grown seed. This mixture of seed can easily be detected if one will examine pure French stock in comparison with pure American stock. The pure French seed of Golden Self Blanching is very much smaller than pure seed of the American Golden Self Blanching. There is also a difference in the growth of the plants, for the French plants are smaller and more compact, than the plants from the American seed..

A grower by careful attention and observation can soon be able to tell the difference in seed so as not to be imposed upon by dealers selling mixed seed. The temptation to mix seed comes from the fact that the French seed is worth from one to three dollars per pound more than the American seed.

With the submission of the above report, we feel that we have done about all that is necessary for us to do in order to show that perseverance and forethought must be observed in order to bring the American seed up to the excellent standard of the seed grown by Velmorin. While it still leaves many matters unexplained, it proved beyond doubt, in our minds that it is not climatic conditions, but the seed that causes pithiness in the stalk of celery.

We believe that carelessness somewhere is the cause of this defect in American celery seed. And that just as good seed can be grown in this country as in Europe, if our growers will give the same care and attention to it. In our work it has been the rarest case to find a pithy or green stalk in celery seed that is imported direct from the best growers in Europe. We believe that such a record can be established by our American growers, if they will "rogue" their plants, by removing all plants that are pithy and that do not conform to the type of the variety wanted.

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OF THE

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